

**POSTMORTEM SERUM THYROGLOBULIN LEVELS AS A MARKER  
TO DIAGNOSE NECK COMPRESSION**

*Dissertation submitted in partial fulfilment of  
the requirements for the degree*

**M.D. (Forensic Medicine)**

**BRANCH - XIV**

**INSTITUTE OF FORENSIC MEDICINE**

**MADRAS MEDICAL COLLEGE**

**CHENNAI – 600 003**



**THE TAMIL NADU**

**Dr. M.G.R. MEDICAL UNIVERSITY**

**CHENNAI**

**APRIL 2015**

## **BONAFIDE CERTIFICATE**

This is to certify that the work embodied in this dissertation entitled **“POSTMORTEM SERUM THYROGLOBULIN LEVELS AS A MARKER TO DIAGNOSE NECK COMPRESSION”** has been carried out by **Dr. R.Narendar, M.B.B.S**, a Post Graduate student under my supervision and guidance for his study leading to Branch XIV M.D. Degree in Forensic Medicine during the period of April - 2014 to September - 2014.

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## **DECLARATION**

I, Dr.R.Narendar, solemnly declare that this dissertation titled **“POSTMORTEM SERUM THYROGLOBULIN LEVELS AS A MARKER TO DIAGNOSE NECK COMPRESSION”** is the bonafide work done by me under the expert guidance and supervision of **Dr.R.Vallinayagam M.D.**, Director & Professor, Institute of Forensic Medicine, Madras Medical College, Chennai – 3. This dissertation is submitted to The Tamil Nadu Dr. M.G.R Medical University towards partial fulfilment of requirement for the award of M.D., Degree (Branch XIV) in Forensic Medicine.

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# INSTITUTIONAL ETHICAL COMMITTEE

## APPROVAL LETTER

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Dear **Dr.R.Narendar,**

The Institutional Ethics Committee of Madras Medical College, reviewed and discussed your application for approval of the proposal entitled "**Postmortem serum Thyroglobulin levels as a Marker to Diagnose Neck Compression**" No.11042014.

The following members of Ethics Committee were present in the meeting held on 08.04.2014 conducted at Madras Medical College, Chennai-3.

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We approve the proposal to be conducted in its presented form.

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The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information / informed consent and asks to be provided a copy of the final report.

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INTRODUCTION

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## ABBREVIATIONS

CLIA	Chemi Luminiscence Immuno assay
DIT	Di Iodo Thyronine
ELISA	Enzyme linked immuno sorbent assay
IRMA	Immuno radio metric assay
T3	Tri Iodo Thyronine
T4	Thyroxine
TRH	Thyrotropic releasing hormone
TSH	Thyroid stimulating hormone
TG	Thyroglobulin
TPO	Thyroid peroxidase
MIT	Mono Iodo Thyronine
Ng / ml	Nanogram per milli liter
RIA	Radio Immuno assay

**ABSTRACT FOR THE DISSERTATION TO BE SUBMITTED TO  
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**TITLE: POSTMORTEM SERUM THYROGLOBULIN LEVELS  
AS A MARKER TO DIAGNOSE NECK COMPRESSION**

**Abstract:**

Asphyxia by neck compression occurs mainly in Hanging, Manual strangulation, Ligature strangulation. Even though the signs like Cyanosis, Petechial hemorrhages, Congestion, Fluidity of the blood are called as asphyxial stigmata; these signs are not specific to asphyxia alone. These can also occur in deaths due to other causes also. Sometimes ligature marks, nail mark abrasions, neck muscle contusions can help in suggesting the death is due to neck compression, these findings can be absent if the ligature material is soft and broad or any material intervening between skin and ligature material in hanging and ligature strangulation and usage of gloves by the assailant in manual strangulation. This study suggests that newer scientific markers and methods can be used in autopsies to help the forensic pathologist in such precarious situations to arrive at the cause of death. In this prospective study, Serum Thyroglobulin levels of 25 cases of death due to neck compression taken as study group are compared with serum of 25 cases of death due to other causes

using Chemiluminescence Immuno assay. The results establish that levels of serum thyroglobulin increases in death due to neck compression ( $1061.6 \pm 398.7$  ng / ml) when compared with control group ( $21.8 \pm 2.71$  ng/ml). The level of increase is marked in manual strangulation ( $5103.2 \pm 539.6$  ng/ml) and ligature strangulation ( $4659.9 \pm 2094.2$  ng/ml) than in hanging ( $257.4 \pm 28.03$  ng/ml). The false positive increase in serum thyroglobulin as in cases of carcinoma thyroid, Hashimoto's Thyroiditis is ruled by Histopathological examination of the thyroid gland taken during autopsy.

**Keywords:** Neck compression, Hanging, Ligature Strangulation, Manual strangulation, Thyroglobulin Chemiluminescence Immuno assay Carcinoma Thyroid, Hashimoto's Thyroiditis

## INTRODUCTION

Etymologically the word 'Asphyxia' in Greek means 'Lack of Pulselessness'. But as time progressed the term has come up with the meaning of Lack of oxygen. This may be due to the understanding of the fact that air is necessary for the maintenance of life which is carried via the blood.<sup>1</sup>

The other terms related to asphyxia are

- Hypoxia – inadequate supply of oxygen to the tissues or an impairment of the cell to utilise the oxygen
- Hypoxemia – decreased oxygen in the arterial blood
- Anaemia – decreased oxygen carrying capacity of the blood
- Anoxia – lack of oxygen

From the medico legal point of view, asphyxia can be grouped into Mechanical and Non-Mechanical causes.

Mechanical causes includes

- 1) Pressure to the exterior of the neck: Hanging, Strangulation, etc.
- 2) Obstruction of the airways from the exterior: suffocation, smothering, etc.



- 3) Obstruction of the airways from the interior: Gagging, Choking, etc
- 4) Pressure upon the chest: Traumatic asphyxia
- 5) Occlusion of airways by fluid: Drowning

Non- Mechanical asphyxia can happen when the environmental oxygen is replaced by other gases, Body cannot utilise the inhaled oxygen, the environmental oxygen is insufficient

Ex: Carbon monoxide poisoning, Cyanide poisoning, etc.<sup>2</sup>

Neck compression is a common mode of death that can happen in Hanging and Strangulation. However many anatomical and physiological factors may operate in combinations leading to death. The important factors are occlusion of the airway either by compression of larynx and trachea or upward lifting of the tongue thereby blocking the pharynx, occlusion of the blood vessels either jugular venous system or carotid arteries, Pressure on the carotid sinuses leading to stimulation of vagus nerve thereby causing death by bradycardia or cardiac arrest.

There are some signs which can be seen in most of the asphyxial signs. These signs are called as 'Classical signs of Asphyxia'. They are

- 1) Edema and Congestion of the organs due to obstructed venous return,

- 2) Petechial Hemorrhages due to increased venous pressure and increased permeability and rupture of venules
- 3) Cyanosis increase in the amount of reduced hemoglobin
- 4) Abnormal Fluidity of blood due to increased fibrinolytic activity in the blood.

However these signs are nonspecific and can occur in deaths from other causes also.<sup>3</sup>

So in Post-mortem Examination, The Autopsy surgeon is in need of some specific signs to find out the exact method in which the fatal chain of events was initiated. Some of the specific signs to look out for are

- Ligature mark in deaths of Hanging and Ligature Strangulation.
- Fingernail Abrasions in deaths of Manual Strangulation
- Fluid medium in the air passages and stomach in deaths of Drowning
- Foreign body in the larynx in deaths of Choking, gagging<sup>4</sup>

The ligature mark in the deaths of Hanging and ligature strangulation depends on composition of the ligature material, Mode of application of Ligature, Position of the knot, Period and Degree of Suspension, weight of the body.

The Ligature mark may not be evident

- If any soft broad ligature material is used
- Any material like beard, collar, muffler, any ornament intervenes between ligature material and the skin
- The Point of Suspension is low<sup>2</sup>

In these situations, The Forensic Pathologist is in a precarious situation in coming to the cause of death. Even after thorough Post-mortem examination, Visiting the Scene of Crime, Verbal autopsy with the relatives could not provide the cause of death in some cases. Therefore The Forensic Pathologist may follow some of the scientific investigation techniques in these cases. One such scientific method is Estimation of the Serum Thyroglobulin level in the heart blood which will be elevated in deaths due to asphyxia caused by neck compression.

In this study, Serum Thyroglobulin was estimated in totally 25 cases of death due to Neck compression due to Hanging, Ligature strangulation and Manual Strangulation. Serum Thyroglobulin was also estimated in totally 25 cases Natural Cause, Road Traffic Accident, Train Traffic Accident, Poisoning and fall from height

# **AIMS AND OBJECTIVES**

## **AIMS AND OBJECTIVES**

- 1) To estimate Post-mortem Serum Thyroglobulin levels in heart blood to diagnose Neck Compression.
- 2) To compare the levels of Post-mortem Serum Thyroglobulin levels in various types of Neck Compression.
- 3) To rule out thyroid diseases causing Post-mortem elevation Serum Thyroglobulin levels with Histopathological study of Thyroid gland on autopsy.

# **REVIEW OF LITERATURE**

## **THYROGLOBULIN AND NECK COMPRESSION:**

The idea of using Thyroglobulin to use it as a marker for neck compression was first developed in 1971 by **Yada et al** in Japan where they found out Thyroglobulin in the serum of a strangled infant to be raised in a significant level using Precipitation Electrophoresis.<sup>5, 61</sup>

Later in 1972, **Yada et al** demonstrated the presence of thyroglobulin in heart blood in many cases of death due to strangulation and confirmed that the level of serum thyroglobulin raises in cases of strangulation <sup>6</sup>

In 1973, **Yada et al** demonstrated a comparative study of serum thyroglobulin levels in deaths due to strangulation and cut throat injuries.<sup>7</sup>

In all these studies Yada et al used Precipitation electrophoresis as a tool to estimate serum thyroglobulin levels in heart blood. As the precipitation electrophoresis had poor specificity and sensitivity the researchers shifted on to further sophisticated techniques.<sup>5, 6, 7</sup>

In 1980, **Katsumata et al** compared the results of serum thyroglobulin levels obtained using Precipitation electrophoresis and Radio immuno assay and found out that Radio immuno assay<sup>8</sup> as a sensitive and specific tool than Precipitation electrophoresis.<sup>9</sup>

Later on Enzyme linked Immuno sorbent Assay (ELISA) superseded the usage of Radio immunoassay (RIA) in the field of Forensic medicine. This led to the shift of detecting the serum thyroglobulin using Enzyme linked Immuno sorbent Assay (ELISA) rather than Radio immunoassay (RIA). Many comparative studies were conducted by Katsumata et al between the years 1980 -1985 to study the sensitivity and specificity of Enzyme linked Immuno sorbent Assay (ELISA) and Radio immunoassay (RIA). The sensitivity of the Enzyme linked Immuno sorbent Assay (ELISA) was 5 ng /ml and the sensitivity of Radio immunoassay (RIA) was 4 ng / ml.

**Tamaki et al** in 1987 published a paper on the usage of Plasma thyroglobulin in the post-mortem diagnosis of mechanical asphyxia. They found out that plasma thyroglobulin levels in 12 out of 14 victims died due to neck compression was higher than 200 ng/ml while all of the victims died due to other causes showed plasma thyroglobulin levels lesser than 200 ng/ml. The sensitivity of the Enzyme linked Immuno sorbent Assay (ELISA) was 5 ng /ml. They concluded that there is a direct correlation between the levels of plasma thyroglobulin levels and neck compression however the diseases causing the raise in plasma thyroglobulin levels must be ruled out.<sup>10</sup>



**Tamaki et al** extended their study on the usage of Plasma thyroglobulin in the post-mortem diagnosis of in 1990 at the Nagoya University in Japan. Plasma thyroglobulin levels in 36 victims died due to other causes other than neck compression showed less than 200ng/ml and plasma thyroglobulin levels in 42 victims died due to neck compression showed more than 200 ng /ml and the highest plasma thyroglobulin level were 24600 ng/ml. The mean of Plasma thyroglobulin levels in Hanging cases were 833ng/ml (n=3), ligature strangulation 2300 ng/ml (n=25), Manual strangulation 2280 ng/ml (n=14) and of other cases 73.6 ng/ml (n=36). They concluded that the thyroglobulin level will be raised in deaths due to neck compression and however thyroid pathology is encountered rare in autopsies the thyroid gland must be dissected out to look for any pathology in thyroid gland by Histopathological examination.<sup>11</sup>

**Muller et al** in 1988 at Dresden University in Germany did a similar study concluding that there is a direct correlation with the increase of Plasma thyroglobulin levels and Strangulation.<sup>15</sup>

**Muller et al** in 1990 correlated the increased levels of Thyroglobulin with the various types of neck compression like Hanging, Manual strangulation and Ligature strangulation.<sup>11</sup>

**Muller et al** published a paper in Forensic science International titled Thyroglobulin and violent asphyxia with the conclusion that there is significant raise in the serum thyroglobulin levels in deaths due to Hanging, Manual strangulation and Ligature strangulation. There was a significant rise in thyroglobulin levels in cases of manual strangulation as compared to ligature strangulation and hanging. The mean values of thyroglobulin levels in Throttling were 561.6 ng/ ml, Ligature strangulation was 193.1 ng /ml and Hanging was 149.9 ng /ml. The mean values of thyroglobulin levels in deaths due to other violent deaths were 17.3 ng /ml.<sup>12</sup>

**Franke et al** published a journal in 1995 published that the thyroglobulin can be used a tool in forensic medicine and research using Immuno Radiometric assay<sup>16</sup>

**Encyclopedia of Forensic Medicine** also states that the serum Thyroglobulin levels can be used as to determine the mode of neck compression whether it is Hanging, Manual strangulation and Ligature strangulation.<sup>17</sup>

## **ANATOMY OF NECK STRUCTURES:**

Neck forms an important part of the body connecting the head with the other parts of the body. It extends from the base of the cranium and lower border of mandible to the thoracic inlet. It contains major blood

vessels like Carotid arteries and Jugular veins, Vagus nerve, Larynx, Trachea, Oesophagus, Thyroid gland, Parathyroid glands.

The layers of the neck consists of

- 1) Skin
- 2) Superficial fascia containing Platysma, Anterior Jugular veins.
- 3) Deep cervical fascia
- 4) Deep structures<sup>18</sup>

The skin of the neck is normally under tension and the direction in which this is greatest varies according to the region.

Platysma is a sheet of superficial muscle arising from the fascia covering the upper parts of pectoralis major and deltoid. The fibres of platysma cross the clavicle and ascend medially. The anterior fibres interlace across the midline with the fibres of the opposite muscle fibre, below and behind the symphysis menti. The Other fibres attach to the lower border of the mandible or to the lower lip or cross the mandible to attach to skin and superficial layer of the face.

The deep cervical fascia of the neck or the fascia colli condenses to form the following layers.

- 1) Investing layer
- 2) Pretracheal layer

- 3) Prevertebral layer
- 4) Carotid sheath
- 5) Buccopharyngeal fascia
- 6) Pharyngobasilar fascia

The deep structures lying above the hyoid bone includes

- 1) Suprahyoid muscles
- 2) Superficial part of submandibular salivary gland
- 3) Mylohyoid nerve and vessels
- 4) Submental branch of facial artery

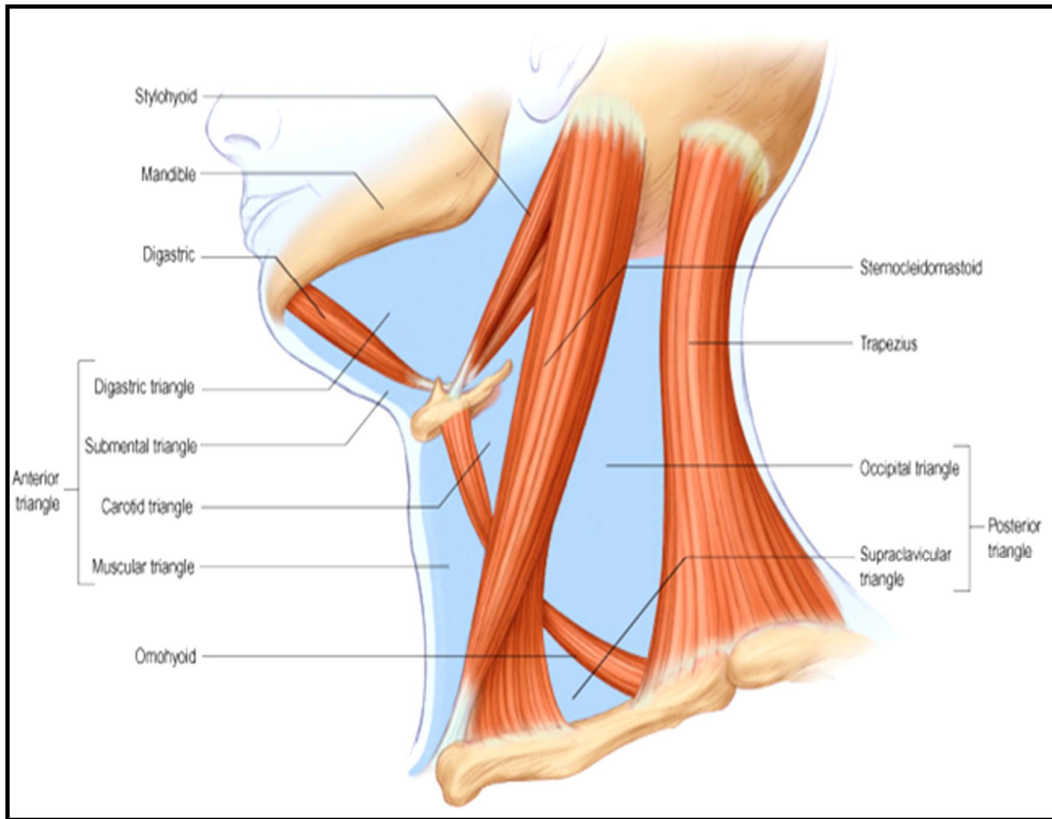
The deep structures lying below the hyoid bone are divided in three planes

- 1) Infrahyoid muscles
- 2) Pretracheal fascia and thyroid gland

Deep plane containing Larynx, Trachea and structures associated with them.<sup>19</sup>

The neck is divided by the Sternocleidomastoid muscle into Anterior and Posterior Triangle.

**Fig.1 : The triangles of the neck**



The anterior triangle is subdivided by the digastric muscle and the superior belly of omohyoid muscle into four triangles.

- 1) Submental triangle
- 2) Digastric triangle
- 3) Carotid triangle
- 4) Muscular triangle

The main contents of the Submental Triangle are Submental lymph nodes and submental veins.

The main contents of the Digastric triangle are submandibular salivary gland, submental artery, mylohyoid nerve and vessels, Internal carotid artery, Internal jugular vein and the vagus nerve

The main contents of the Carotid triangle are The common carotid artery and its termination, Internal & External carotid arteries, Internal jugular vein, Common facial vein, Lingual vein, Vagus nerve, Superior Laryngeal nerve, Hypoglossal nerve ,Spinal accessory nerve and Sympathetic chain

The main contents of the Muscular triangle are the infrahyoid muscles – Sternohyoid, Sternothyroid, Thyrohyoid and Omohyoid

The posterior triangle is further subdivided by the inferior belly of omohyoid into two triangles

1) occipital triangle

2) supraclavicular triangle

The main contents of the occipital triangle are Occipital artery, Spinal accessory nerve

The main contents of the supraclavicular triangle are the three trunks of the brachial plexus, nerve to subclavius, Nerve to serratus anterior,

suprascapular nerve, third part of subclavian artery, suprascapular artery and vein and lower part of external jugular vein.

The other structures seen in the neck are the Thyroid Gland, Submandibular Salivary Gland, Cervical portions of the Trachea and the Oesophagus.<sup>20</sup>

## **ANATOMY OF THYROID GLAND**

Thyroid (shield like) gland is one of the largest endocrine gland located in the front of neck situated anterior and lateral to the junction of larynx and trachea just inferior to the thyroid cartilage

It is a butterfly shaped gland with bilobed structure having two lateral lobes connected by a midline isthmus. Occasionally there may be a pyramidal lobe which represents the distal part of the thyroglossal duct which can be seen from isthmus to as above as hyoid bone.

Each lateral lobe extends from the middle of thyroid cartilage to the 4<sup>th</sup> or 5<sup>th</sup> Tracheal ring opposite C 5, C 6, C 7 and T 1 Vertebrae.<sup>21</sup>

The size of the thyroid gland is variable and it depends on heredity, environment and nutritional factors. The average weight is about 34 g (1.2 oz).

The gland is slightly heavier in females and enlarges during menstruation and pregnancy. The Thyroid gland has a deep red coloration because of the increased vascularity of the gland due to large number of blood vessels supplying the gland.<sup>21</sup>

There are two capsules for the thyroid gland,

- 1) The true capsule formed by the peripheral condensation of the connective tissue of the thyroid gland
- 2) The False capsule formed by the pretracheal layer of the deep cervical fascia which is thin on the posterior border of the lateral lobes and thick on the inner surface of the gland where it is called as the 'Suspensory ligament of Berry' which connects the lateral lobes to the cricoid cartilage.

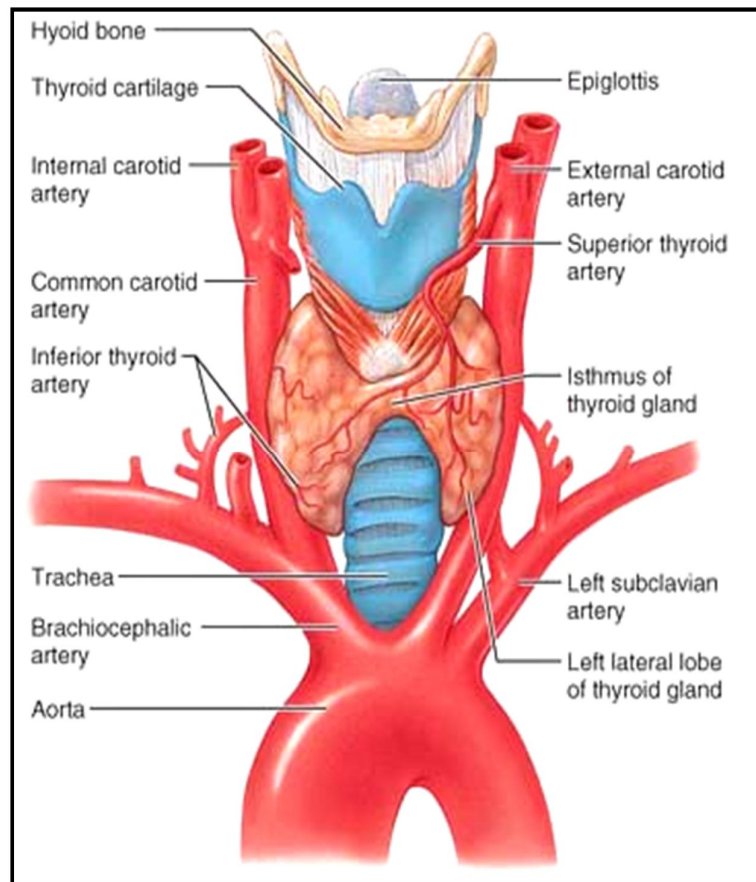
The lateral lobes are conical in shape having an apex, base, three

Surfaces - Lateral, Medial and Postero- Lateral, Two Borders- Anterior and Posterior.

The Isthmus has two surfaces-anterior and posterior, two borders - superior and inferior<sup>19</sup>



**Fig.2 showing the Thyroid gland and its anatomic relations**



## **BLOOD SUPPLY OF THE THYROID GLAND**

The Arterial supply to the Thyroid gland is mainly by Two pairs of Superior Thyroid artery and Inferior Thyroid artery.

The Superior Thyroid artery is a branch of the External Carotid artery which arises just immediately above the bifurcation of the common carotid artery. The Superior Thyroid artery passes medially onto the surface of the inferior pharyngeal constrictor muscle and it enters the apex of the superior

pole. As the Superior Thyroid artery progresses medially, it is adjacent to the external branch of the superior laryngeal nerve.

The Inferior Thyroid artery arises from the thyrocervical trunk. It ascends into the neck behind the carotid sheath and then it arches medially to enter the thyroid gland posteriorly usually near the ligament of Berry. There is usually no direct arterial supply to the thyroid inferiorly. The recurrent laryngeal nerve is usually directly adjacent to the inferior thyroid artery in either anterior or posterior position. The Inferior thyroid artery mostly supplies both the superior and inferior parathyroid glands

Occasionally a thyroidea ima artery may be present in less than 5% of patients and it usually arises directly from the innominate artery or from the aorta.

There are Three pairs of venous systems draining the thyroid gland. Superior Thyroid veins are just immediately adjacent to the superior thyroid arteries and they join the internal jugular vein at the level of the carotid bifurcation. Middle Thyroid veins are present in more than half of individuals and they course immediately laterally into the internal jugular vein. The inferior Thyroid veins are usually two to three in number and they descend directly from the lower pole of the thyroid gland into the innominate and brachiocephalic veins. Occasionally a fourth thyroid vein (of

Kocher) may be present between middle and inferior thyroid veins which may drain into the internal jugular vein.<sup>21</sup>

## **EMBRYOLOGY OF THYROID GLAND**

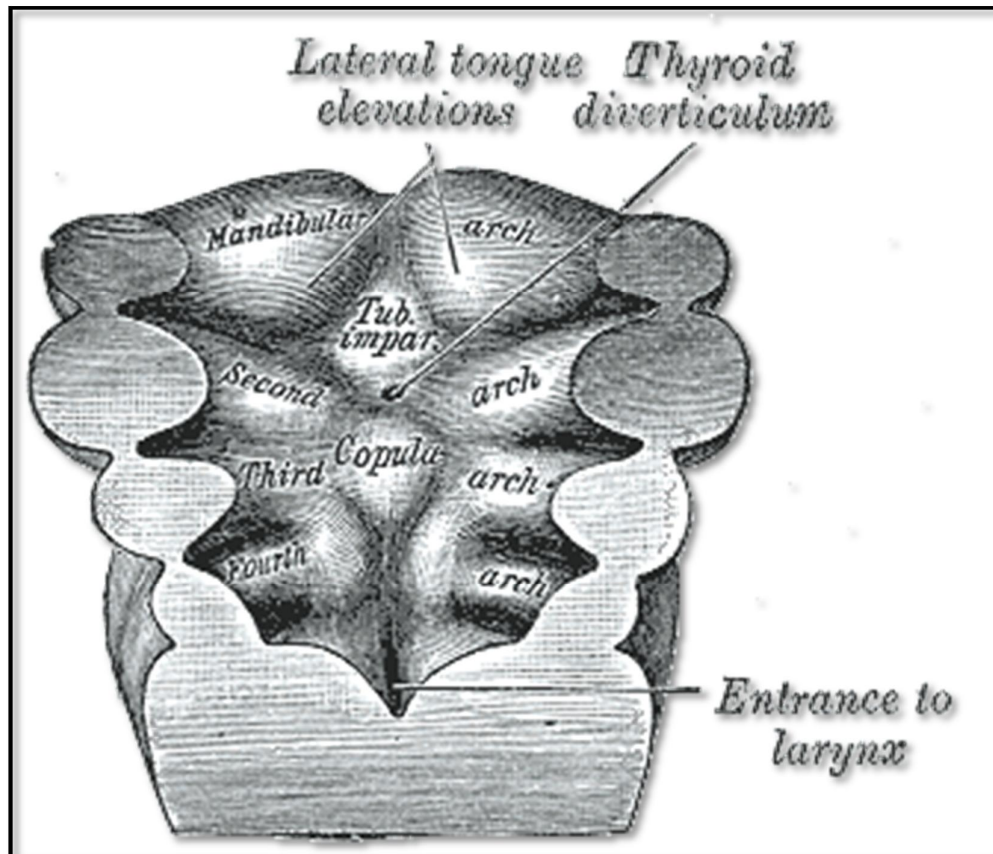
The Thyroid gland arises initially as a tissue bud from a midline diverticulum in the floor of the pharynx. The main portion of this structure descends into the neck and develops into a butterfly shaped bilobar solid organ. In the pharynx, the original attachment is the foramen cecum located in the buccal cavity. This structure becomes the thyroglossal duct, which is reabsorbed after 6 weeks of age. The very distal end of this duct may occasionally be retained and form as a pyramidal lobe in the adult thyroid.<sup>22</sup>

Microscopic thyroid follicles first appear as the lateral lobes of the thyroid gland develops. When the embryo is about 6 cm in length, these follicles begins to develop colloid. In the third month the cuboidal follicular cells first demonstrate iodine trapping, and thyroid hormone secretion initially begins.<sup>23</sup>

Calcitonin-producing C cells arise from the fourth pharyngeal pouch and they migrate from the neural crest into the lateral lobes of the thyroid. These C cells migrate into the lateral and posterior upper two thirds of the thyroid lateral lobes and are distributed among the follicles. In adults, they

are present on only in the upper and middle areas of the thyroid gland, usually in the posterior and medial aspects.

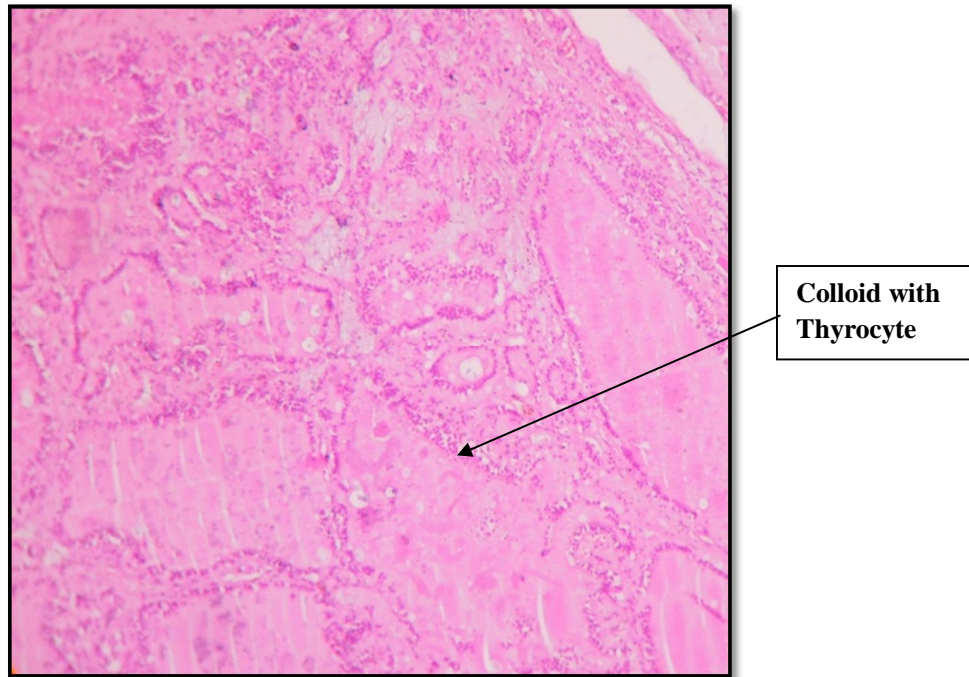
**Fig. 3: the thyroid diverticulum which gives rise to the thyroid gland**



## **HISTOLOGY OF THYROID GLAND**

The thyroid gland covered by a fibrous capsule is divided into lobules by septa extending from the capsule. Each lobule is made up of aggregation of follicles (100 to 300 micrometers). The portion of the thyroid gland concerned with the production of thyroid hormone consists of multiple acini or follicles.<sup>24</sup>

**Fig.4 : Normal Histology of the Thyroid gland**



Each spherical follicle is surrounded by a single layer of epithelial cells and filled with pink stained proteinaceous material called colloid. Colloid consists mainly of the thyroglobulin, a glycoprotein produced from the endoplasmic reticulum and the golgi body of the follicular cells.

When the gland is inactive, the colloid content is abundant, the follicles are large, and the follicular cells lining them are flat. When the gland is active, the follicular cells are small, the cells are cuboid or columnar, and areas where the colloid is being actively reabsorbed into the thyrocytes are visible as "reabsorption lacunae"

Microvilli project into the colloid from the apexes of the thyroid cells and canaliculi extend into them. The endoplasmic reticulum is prominent, a feature common to most glandular cells, and secretory granules containing thyroglobulin are seen. The individual thyroid cells rest on a basal lamina that separates them from the adjacent capillaries. The capillaries are fenestrated, similar to those of other endocrine glands<sup>25</sup>

### **PHYSIOLOGY OF THYROID GLAND:**

Of the metabolically active hormones secreted by thyroid gland, About 93 per cent is Thyroxine (T<sub>4</sub>), and 7 per cent Triiodothyronine (T<sub>3</sub>). However, almost all the thyroxine is converted to Triiodothyronine in the tissues. The functions of both these hormones are qualitatively the same. They differ in rapidity and intensity of action. Triiodothyronine (T<sub>3</sub>) is four times as potent as thyroxine. It is present in the blood in smaller quantities and also persists for a much shorter time than thyroxine.<sup>26</sup>

Iodine is a key requirement in the formation of thyroid hormones and a minimum of ingestion of 1mg/week is needed for the adequate formation of the thyroid hormones. The steps in the formation of thyroid hormone synthesis are

- 1) Iodide trapping
- 2) Oxidation of the iodide ion
- 3) Organification
- 4) Coupling<sup>27</sup>

### **Iodide trapping:**

The first and foremost important step in the formation of thyroid hormones is the transport of ingested iodides into the follicular epithelial cells of the thyroid gland by the sodium and Iodide( $\text{Na}^+/\text{I}^-$ ) symporter in the basolateral membrane of the thyrocytes. This is a energy dependant process and is mainly regulated by the level of Thyroid stimulating hormone (TSH).<sup>28, 30</sup>

### **Oxidation:**

The trapped iodide ion must be transported across the apical membrane to reach the thyroglobulin molecule. This is facilitated by the  $\text{Cl}^-/\text{I}^-$  Exchanger in the apical membrane, also called as Pendrin. During this exchange another enzyme Thyroid peroxidase converts the trapped iodide into Iodine.

**Organification:**

The Iodine molecule is attached to the Carbon 3 position of the tyrosine residues in the thyroglobulin molecule in the colloid.<sup>29</sup> This reaction is called as organification and it is mediated by the enzyme Iodinase. One tyrosine aminoacid attached to one Iodine constitutes Mono Iodo Tyrosine (MIT). If two Iodine attaches to the Carbon 3 and 5 of the Tyrosine, it is called as Di Iodo Tyrosine (DIT).

**Coupling:**

The two molecules of Di Iodo Tyrosine(DIT) combines to form Thyroxine(T4) and one molecule of Di Iodo Tyrosine(DIT) comes with one molecule of Mono Iodo Tyrosine(MIT) to form Triiodothyronine(T3). This coupling reaction occurs within the thyroglobulin molecule. In the normal thyroid, the average distribution of iodinated compounds is 23% MIT, 33% DIT, 35% T4, and 7% T3.

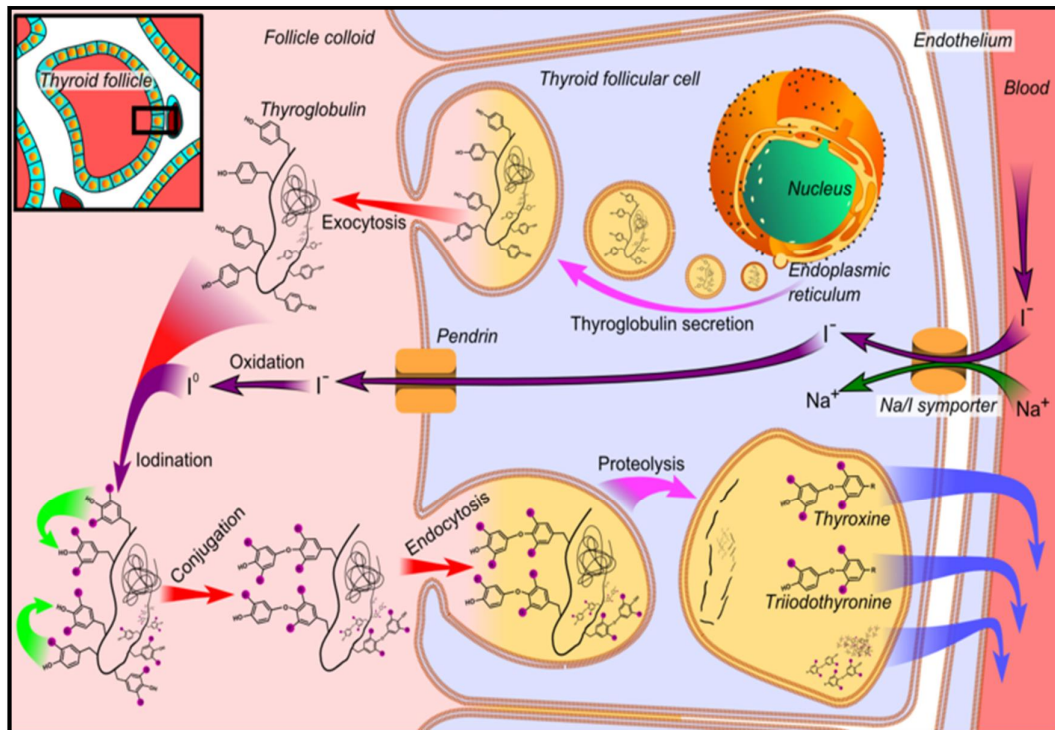
**Release of Thyroid hormones:**

On appropriate stimulation, the apical membrane extends pseudopods to pinocytose Thyroglobulin molecules so that they are cleaved by the intracellular lysosomes to release only Thyroxine and Triiodothyronine(T3) from the basolateral membrane into the bloodstream. Remaining Di Iodo



Tyrosine(DIT) and Mono Iodo Tyrosine(MIT) are recycled back to the colloid.<sup>30, 31, 32</sup>

**Fig. 5 : The synthesis of the thyroid hormone and the role of Thyroglobulin**



## NORMAL PHYSIOLOGICAL EFFECTS OF THYROID HORMONES

### 1) Basal metabolic rate (BMR)/ temperature regulation

- Promotes normal oxygen use and BMR
- Increases calorogenesis
- Enhances effects of sympathetic nervous system

## **2) Carbohydrate/ Lipid/protein metabolism**

- Promotes glucose catabolism
- Mobilizes fats
- Essential for protein synthesis
- Enhances liver's synthesis of cholesterol

## **3) Nervous system**

- Promotes normal development of nervous system in fetus and infant
- Promotes normal adult nervous system function

## **4) Cardiovascular system**

- Promotes normal functioning of the heart

## **5) Muscular system**

- Promotes normal muscular development and function

## **6) Skeletal system**

- Promotes normal growth and maturation of the skeleton

## **7) Gastrointestinal system**

- Promotes normal GI motility and tone
- Increases secretion of digestive juices

## **8) Reproductive system**

- Promotes normal female reproductive ability and lactation

## **9) Integumentary system**

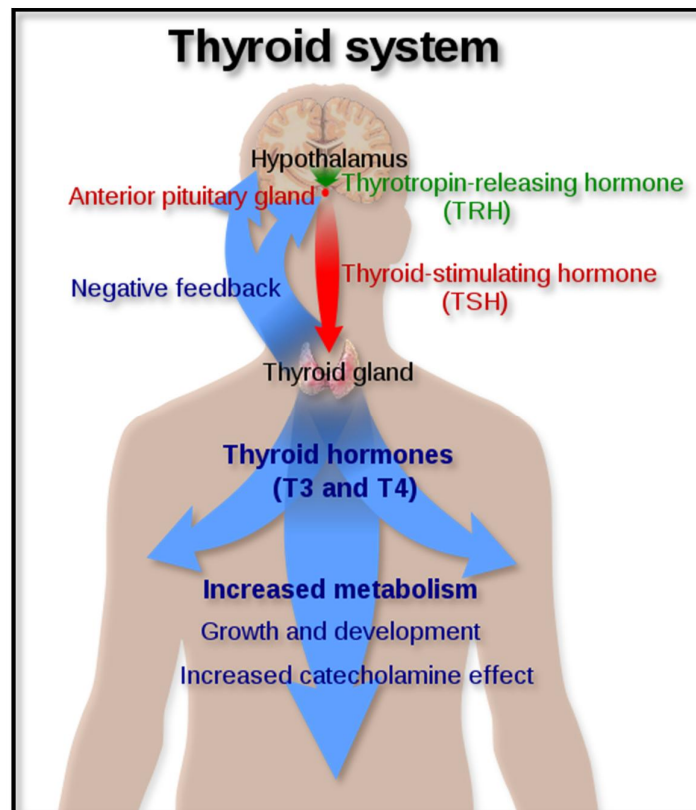
- Promotes normal hydration and secretory activity of skin

## **REGULATION OF THYROID HORMONES:**

Thyroid gland is under the negative feedback control by the Thyroid Stimulating Hormone (TSH) which is produced by the anterior pituitary gland. Thyroid Stimulating Hormone is under the negative feedback control by the Thyrotropin releasing hormone (TRH) produced by the hypothalamus

When the body need thyroid hormones it is released by the thyroid gland under the influence of Thyroid Stimulating Hormone. Thus in hypothyroidism the thyroid hormone (T3 and T4) levels are low which can be confirmed by the high levels of Thyroid Stimulating Hormone. In hyperthyroidism the thyroid hormone (T3 and T4) levels are high which can be confirmed by the low levels of Thyroid Stimulating Hormone.<sup>32</sup>

**Fig.6 showing regulation of thyroid hormones**



## **THYROGLOBULIN – STRUCTURE & FUNCTIONS**

Thyroglobulin is a large glycosylated protein synthesized from the endoplasmic reticulum and the golgi apparatus of the thyroid follicular cells. It has a molecular weight of 660 KDa with 5000 amino acids.<sup>33</sup> Of the total molecular weight, carbohydrate accounts for 8 – 10 %. Thyroglobulin is made up of two large subunits. It contains 115 tyrosine residues each of the residue is a potential site for iodination. Thyroglobulin has a half-life of 65 hours.<sup>59, 60</sup>

The iodides account for 0.2 – 1 % and it depends on iodide quantity in the diet. About 70% of the iodide in thyroglobulin exists in the inactive precursors monoiodotyrosine (MIT) and diiodotyrosine (DIT) and 30% is in the iodothyronyl residues Thyroxine(T4) and TriIodoThronine(T3). When iodine in the diet is sufficient, the T4:T3 ratio is about 7:1. In iodine deficiency, the ratio decreases as well as the DIT: MIT ratio.

As said earlier, Thyroglobulin is synthesized from the endoplasmic reticulum and the golgi apparatus of the thyroid follicular cells near the basal portion of the cell. It is transported across the membrane into the colloid where it acts as a pre hormone in the formation of T3 and T4. The third and fourth stages of thyroid hormone synthesis namely organification and coupling occurs in the thyroglobulin molecule.

Then the thyroglobulin molecule acts a storage form for thyroid hormones .several weeks supply of thyroid hormones are stored in the thyroglobulin so that when there is a stimulation by TSH, the whole thyroglobulin molecule is endocytosed by the pseudopods from the apical membrane of the thyrocytes.

Then by the phagolysosomal activity of the cell, the thyroglobulin molecule is cleaved to release the thyroid hormones into the circulation

from the basal portion of the cells. Remaining Di Iodo Tyrosine(DIT) and Mono Iodo Tyrosine(MIT) are recycled back to the colloid.<sup>33,34</sup>

Thus the Thyroglobulin molecule acts as a

- 1) Pre hormone for the synthesis of thyroid hormones
- 2) Site of synthesis of thyroid hormones
- 3) Storage form of thyroid hormones<sup>35</sup>

Usually for a normal thyroid gland, the reference range of thyroglobulin values is taken as 3 - 40 ng/ml. The values depend on the age of the individual.

**Table 1 illustrating the normal levels of serum thyroglobulin**

Age	Reference Interval
6 months - 3 years	7.4-48.7 ng/mL
4-7 years	4.1-40.5 ng/mL
8-17 years	0.8-29.4 ng/mL
18 years and older	1.3-31.8 ng/mL

## **USES OF THYROGLOBULIN:**

Thyroglobulin is a glycosylated protein which is secreted only by the thyroid gland alone and not anywhere else in the body. Usually it is not secreted into the blood along with the thyroid hormones. But it can be found in very minute amounts only. The reference range of thyroglobulin values is taken as 3 - 40 ng/ml.<sup>36</sup>

In Thyroid Carcinomas Usually of Papillary and Follicular type, the thyroglobulin levels are increased due to destruction of the follicles and release of thyroglobulin from the colloid into the blood stream. Therefore the thyroglobulin is used as a tumour marker in Thyroid Carcinoma and the levels are studied in the Post operative period following Total Thyroidectomy procedures for Thyroid Carcinomas to look for any recurrence of the carcinoma or any remaining thyroid tissue after surgery.<sup>37</sup>

### **Factors which may affect the values of thyroglobulin levels:**

The following are the factors affecting the Thyroglobulin levels.<sup>38</sup>

1. Thyroid carcinoma
2. Hashimoto's Thyroiditis
3. Graves disease
4. Toxic Multinodular goitre

**Thyroid carcinoma:**

Thyroid carcinomas are mainly of four types. They are

1. Papillary carcinoma
2. Follicular carcinoma
3. Medullary carcinoma
4. Anaplastic carcinoma

Some other carcinomas are Hurthle cell carcinoma, Mixed Papillary and follicular carcinomas.

Papillary carcinoma is the most common type of thyroid carcinoma most commonly occurring in the females of less than 40 years. They have an excellent prognosis if detected and treated earlier. On Histopathological examination, it shows a typical pattern of Orphan anne nuclei. They can be classified into well differentiated and poorly differentiated carcinoma on Histopathological examination.

Follicular carcinoma is the second most common thyroid carcinoma occurring most commonly in older females. They have a good prognosis with less mortality rate. It most commonly occurs in the functioning thyroid gland.



Medullary carcinoma occurs in the Parafollicular C Cells and Anaplastic Carcinoma occurs in the elderly individuals. Both these are less common thyroid malignancies and have bad prognosis with an increased mortality rate.

Papillary and Follicular Carcinoma can raise the serum thyroglobulin levels due to the destruction of the follicles. They can interfere with the values in the study, thus giving false positive and are promptly ruled out by the Histopathological examination of the thyroid gland taken out during the autopsy.<sup>39, 57, 58</sup>

### **Hashimoto's Thyroiditis:**

Hashimoto's thyroiditis is an autoimmune disease characterised by the presence of antibodies to normal thyroid tissue. The antibodies in Hashimoto's thyroiditis are mainly of three types. They are

1. Antibody to Thyroglobulin
2. Antibody to thyroid peroxidase and
3. Antibody to TSH Receptor

These antibodies mediate complement fixation and killing by Natural killer cells (NK cells). Hashimoto's thyroiditis is also mediated by CD 4 + T Lymphocytes activation which recruit CD 8 + Lymphocytes which causes thyroid destruction leading to increased level of serum thyroglobulin level.

Hashimoto's thyroiditis is commonly seen in women and mostly presents as a firm nodular gland with features of hypothyroidism. 5 % of the patients may present with features of hypothyroidism. On gross examination the thyroid gland is mildly enlarged throughout and has a granular, nodular and firm surface.<sup>21</sup>

On microscopic examination the gland is diffusely infiltrated by small lymphocytes and plasma cells. Thyroid follicles are smaller with reduced amounts of colloid and increased interstitial tissue. The follicles are lined by Hurthle or Askanazy cells which are characterized by abundant eosinophilic, granular cytoplasm.

If present in cases of neck compression it produces false positive results and hence it can be eliminated by histopathological study of the thyroid gland.

### **Graves's disease:**

Graves's disease or diffuse toxic goitre is an autoimmune disease with more female preponderance characterised by diffuse goitre, thyrotoxicosis, ophthalmopathy. The thyroid-stimulating antibodies stimulate the thyroid epithelial cells to grow and synthesize excess thyroid hormone which is a hallmark of Graves' disease. They cause recruitment of CD 4+ and CD 8+ lymphocytes which then cause the destruction of the

thyroid gland leading to false positive increase in serum thyroglobulin levels.

On Gross the thyroid gland in patients with Graves' disease is diffusely enlarged with increased vascularity. Microscopically the gland is hyperplastic and the epithelium is columnar with minimal colloid. There may be aggregates of lymphoid tissue and vascularity is markedly increased.

Graves's disease produces false positive rise in serum thyroglobulin levels and hence on post-mortem examination it can be ruled by histopathological examination of the thyroid gland.<sup>37, 42</sup>

### **Toxic Multinodular goitre:**

Toxic multinodular goitre most commonly arises in the long standing non toxic multinodular goitre and has a female preponderance. This also presents with destruction of the thyroid gland leading to false positive increase in serum thyroglobulin levels and hence on post-mortem examination it can be ruled by histopathological examination of the thyroid gland.<sup>40, 43</sup>

### **ASPHYXIA:**

As stated earlier, Asphyxia means 'Pulselessness'. But as time progressed the term has come up with the meaning of Lack of oxygen.

According to **Adelson** asphyxia is the physiologic and chemical state in a living organism in which acute lack of oxygen available for cell metabolism is associated with inability to eliminate excess of carbon dioxide.<sup>41</sup>

The word Anoxia originally means lack of oxygen.

**Barcroft** divided Anoxia into three types.

- 1) Anoxic anoxia – due to prevention of oxygen from reaching the lungs
- 2) Anaemic anoxia – due to decreased oxygen carrying capacity of the blood due to low hemoglobin
- 3) Stagnant anoxia – due to impaired circulation of blood <sup>44</sup>

**Peters and Van Slyke** added the fourth type of anoxia

- 4) Histotoxic anoxia – due to non utilisation of the freely available oxygen by the cells.

Histotoxic anoxia is further subdivided into

- a) Extracellular – tissue oxygen enzyme system is inactivated as in Cyanide poisoning

- b) Pericellular – oxygen cannot permeate cells due to lipid soluble anaesthetic agents as in chloroform, halothane, etc.
- c) Substrate – there is inadequate food for cell's metabolism
- d) Metabolic – the end products of the cellular respiration cannot be removed as in uraemia or carbon dioxide poisoning<sup>44</sup>

### **CLASSICAL SIGNS OF ASPHYXIA:**

The so called classical signs of asphyxia are non specific and can also occur in deaths due to other causes.

1. Cyanosis
2. Congestion
3. Fluidity of blood
4. Petechial hemorrhages<sup>45</sup>

### **CYANOSIS:**

Cyanosis in Greek means 'dark blue'. Cutaneous cyanosis depends mostly on the absolute amount of reduced hemoglobin rather than the amount of oxy hemoglobin. There must be at least 5 gm % of reduced hemoglobin before cyanosis becomes evident irrespective of the amount of hemoglobin.<sup>46</sup>

In neck compression cyanosis follows congestion of face due to much amount of reduced hemoglobin in venous blood and also partly due to the compression of the airway leading to reduced oxygenation of the blood in the lungs. This depends on the complete or partial obstruction of the airway.

When the deceased is examined within few hours of death the presence of cyanosis is of some significance. The appearance of cyanosis after 24 hours may be even due to the post-mortem changes. Absence of cyanosis within few hours of death does not signify that cyanosis was present at the time of death.

Cyanosis can also occur in other forms of death. So it is a non specific sign of asphyxia.<sup>47</sup>

### **CONGESTION:**

Congestion of viscera in asphyxia deaths is due to the capillo venous dilatation which occurs due to the susceptibility of the capillaries to hypoxia. It leads to dilatation of capillaries resulting in stasis of blood in the capillaries and venules. This is not specific only for deaths due to interference in respiration but also to deaths due to other causes also.

Congestion may be important finding in neck compression if the congestion above the level of neck compression is more marked that may help in finding the manner of death as homicidal activities like Manual and

Ligature strangulation. Usually in hanging the congestion above the ligature mark is minimal when compared to strangulation.<sup>47, 48</sup>

### **PETECHIAL HEMORRHAGES:**

Petechial hemorrhages otherwise called as Tardieu spots are pinpoint hemorrhagic spots seen mostly in the visceral pleura and epicardium were first described a French Police surgeon Tardieu<sup>49</sup> in 1866. He said that these were pathognomic of deaths due to mechanical asphyxia. Later in 1944 Gordon and Lime found these kinds of petechial hemorrhages in many forms of death.<sup>50, 51</sup>

Shapiro, in 1955 described that some of the petechial hemorrhages were post mortem artefacts and disappeared in very short period.<sup>52</sup> In 1981 Zaini and Knight confirmed that only one third of these petechial hemorrhages were due to mechanical asphyxia and res two thirds were false.<sup>53</sup>

These Tardieu spots develop due to the following factors

1. Increased stasis of blood in the venules causing congestion which leads to the increased venous pressure causing rupture of the venules
2. Increased capillary and venous permeability due to hypoxia

## **FLUIDITY OF BLOOD:**

The fluidity of the blood in deaths due to mechanical asphyxia may be due to activation of the fibrinolytic system leading to increased levels of fibrinolysins. However the fluidity and the amount of fibrinolysin mostly depend on the rapidity of death rather than the nature of death.<sup>48</sup>

## **NECK COMPRESSION - TYPES**

From the medico - legal point of view, asphyxia can be grouped into Mechanical and Non-Mechanical causes.

Mechanical causes includes

1. Pressure to the exterior of the neck : Hanging, Strangulation, etc.
2. Obstruction of the airways from the exterior: suffocation, Smothering, etc.
3. Obstruction of the airways from the interior: Gagging, Choking, etc
4. Pressure upon the chest: Traumatic asphyxia
5. Occlusion of airways by fluid: Drowning

Neck compression can happen in many ways. The main occurrences where neck compression can be attributed to death are the following :



1. Hanging
2. Strangulation – Ligature Strangulation or Manual Strangulation or Throttling
3. Other forms of Neck Compression – Mugging, Garotting, bansdola, Strangulation in the bend of knee, Foot Strangulation<sup>54</sup>

## **HANGING:**

Hanging is one of the forms of neck compression causing asphyxia which is caused by suspension of the body by a ligature encircling the neck where the constricting force being the weight of the body<sup>2</sup>

### **Types of Hanging:**

Hanging can be classified based on various categories.

1. Position of Knot:
  - A. Typical hanging
  - B. Atypical hanging
2. Position of feet:
  - A. Complete hanging
  - B. Partial hanging
3. Manner of hanging:
  - A. Suicidal
  - B. Homicidal
  - C. Accidental

#### 4. Mode of hanging:

- A. Judicial
- B. Sexual
- C. Lynching

#### **Complete hanging:**

Complete hanging is a type of hanging where the body is fully suspended in the air with the foot does not touching the ground and the constricting force is the weight of the body <sup>2,3</sup>

#### **Incomplete hanging:**

Incomplete hanging is a type of hanging where the body is not fully suspended in the air with the toes, foot, knees, buttocks does touch the ground and the constricting force is the weight of the head (about 5 -6 kg). <sup>2,3</sup>

#### **Typical Hanging:**

Typical Hanging is a type of hanging where the position of the knot is present over the occipital region and the ligature mark is prominent over the front of the neck. <sup>2,3</sup>

#### **Atypical Hanging:**

Atypical Hanging is a type of hanging where the position of the knot is present in other region other than the occipital region.

**Suicidal Hanging:**

Most commonly hanging is a mode of suicide. According to National crime records bureau statistics of 2013 shows that 37 % of the suicidal deaths in India are due to Hanging. Tamil Nadu tops the list of number of suicides in the country and in hanging Tamil Nadu comes in the third place.<sup>63, 64</sup>

Age of the victim can be in both extremes of life and both the sexes are prone for this mode of death. Suicidal Hanging can be corroborated with evidences like suicide notes in the deceased handwriting, secluded place of occurrence, very easily approachable point of suspension and easily accessible ligature material.<sup>47</sup>

**Accidental Hanging:**

Accidental hanging can occur while at work, during playing, exhibiting hanging exercises or showing some performances in the circus, auto erotic masochistic sexual exercises, etc. It can also occur when a person's neck gets compressed below the chin by getting suspended from a steering wheel of a car, edge of a sofa or an arm of a chair.

While at work for example in a factory, a worker may fall from a height and get caught between slings or rope or a labourer carrying load on his back may slip and cause accidental hanging. Children can get

accidentally hanged if a restraining apparatus slips or a cloth tightened around the neck while crawling.<sup>48</sup>

### **Homicidal Hanging:**

Homicidal hanging is very rare but can occur if the victim is a child, incapacitated by drugs or alcohol, or if the victim is rendered unconscious by a blow to the head. It is obvious that homicidal hanging to be accomplished single handedly. There may be evidence of dragging or pulling the victim as evidence of friction. The hands of the victim may show some foreign materials like hair, button and piece of clothing. There may be signs of struggle or presence of injuries on the body<sup>48</sup>

### **LYNCHING:**

The term Lynch means to put a person to death by a mob action for an alleged offence without a legal trial. It was named after Captain W Lynch who practiced this mode of hanging in Virginia. At first the victim is beaten with iron rods by the mob and after he falls unconscious he is dragged to the village square to be hanged till death.<sup>2,3</sup>

### **POSTMORTEM FINDINGS IN HANGING:**

The post-mortem findings in hanging depends on the mechanisms of death caused by hanging

## **EXTERNAL FINDINGS:**

### **FACE:**

The face in case of hanging may be pale if the death is due to vagal inhibition or if there is any injury to the spinal cord. The face may appear congested if the death is due to asphyxia and if it is due to apoplexy it is markedly congested.

If the hanging is complete there will be occlusion of carotid arteries and the face may be pale with minimal petechial hemorrhages. If the hanging is incomplete there may not be complete occlusion of the carotid arteries and the face appears much congested with increased petechial hemorrhages over face, conjunctivae, forehead, etc <sup>2,3</sup>

### **EYES:**

The eyes may be closed or open. More often the eyes are protruded out with visible petechial hemorrhages in the subconjunctival region. 'La Facies sympathique' is a condition produced when there is a pressure in the cervical sympathetic chain on one side the eye on the same side will remain open with the pupils dilated

**TONGUE:**

The tongue is usually swollen and blue in colour with forcing of the tongue between teeth. The tongue is also pushed upwards against the posterior pharyngeal wall thereby occluding the airway. The protruding part of the tongue is dark in colour with minimal petechial hemorrhages on its surface

**SALIVA:**

Saliva may be found dribbling from the mouth opposite the side of the knot. This may be produced due to the stimulation of salivary glands or due to congestive hypoxia. Dried marks of saliva may be present in the deceased suggesting that the hanging is ante mortem. But the absence of the dried salivary stains will not suggest post-mortem hanging since it may be absent in deaths due to vagal inhibition or injury to the spinal cord.<sup>47</sup>

**HANDS:**

Hands are usually found clenched and may have some fibres of the ligature material or any other material exchanged from the assailant in case of homicidal hanging

**GENITALS:**

Penis may be found engorged due to hypostasis with emission of semen at its tip sometimes. In females the vagina may be found with turgescence with discharge of blood stained fluid sometimes. Urine and faeces may sometimes escape through urethra and anus due to relaxation of sphincters

**POSTMORTEM STAINING:**

If the body is suspended in upright position as per rule the postmortem hypostasis will be found in the dependant part in this case lower limbs, forearm, hands and genitalia. There may be evidence of petechial hemorrhages in the skin of the legs. If the ligature is cut and the body is transferred to supine position before the fixation of the postmortem hypostasis secondary areas of hypostasis will be developed in the dependant parts

**CYANOSIS:**

Cyanosis will be seen in lips, fingernails, tip of nose and ear lobules and the cyanosis may be seen marked if the point of suspension is from a low point

## **LIGATURE MARK:**

The ligature mark is the principle external sign in cases of hanging. It is a type of pressure abrasion most commonly running obliquely around the neck above the level of thyroid cartilage. The ligature mark appears in the form of groove or furrow deepest in the opposite side of the knot. It is usually yellowish or yellowish brown after death but gets dried up due to exudation of tissue fluid assuming parchment like consistency.<sup>87</sup>

When the knot is in the nape of the neck as in typical hanging the ligature mark is more pronounced at the anterior part of the neck. The ligature mark mostly never completely encircles the neck due to intervening hair in the nape of the neck and the firmness of the structures of back of the neck. It assumes the shape of inverted 'v' with the apex of the v corresponding to the site of the knot. Most commonly the knot is located in the either side of the neck or in the nape of the neck. Very rarely it is situated below the chin.<sup>62</sup>

The width of the ligature mark may be equal or less than the width of the ligature material. The ligature mark may be patterned exhibiting the nature of the ligature material. Sometimes the ligature mark may be faint in nature so that it can be examined through histopathological examination to



confirm it. There are various factors influencing the appearance of the ligature mark.<sup>2,3</sup> They are

1. Composition of ligature material
2. Mode of application of ligature
3. Position of the knot
4. Course of ligature around the neck
5. Period and degree of suspension
6. Slipping of the ligature
7. Weight of the body<sup>3</sup>

#### **Composition of ligature material:**

The ligature material may be any kind of material like rope made of cotton, jute, nylon, dhotis, saree, bed sheets, thupattas, belts, brace, etc. In cases of suicidal hanging any of the easily available materials can be used as a ligature material.

The ligature mark is marked and deep if the ligature material is tough and narrow. The ligature mark is less prominent if the ligature material is soft and broad. In a folded cloth producing ligature mark the width and appearance of the ligature mark may vary significantly. In cases of hanging where nylon, Terylene, silk is used as a ligature material the ligature mark may not be significant.<sup>62</sup>

**Mode of application of ligature:**

In most cases of hanging, fixed loop is applied where the ligature mark is seen as obliquely above the level of thyroid cartilage opposite the side of the knot. Ligature marks produced by running noose may have a horizontal pattern mostly above the level of thyroid cartilage

**Position of the knot:**

Most commonly the position of the knot is to the right or left side of the neck as atypical hanging is most common type of hanging. Next is the knot at the nape of the neck. Knot below the chin is very rare in cases of hanging.

**Course of ligature around the neck:**

Ligature mark in hanging is most commonly seen above the level of thyroid cartilage and it runs obliquely around the neck in the form of inverted 'v' with the apex of the v corresponds to the site of the knot. Some studies showed that the ligature mark can be seen at the level of thyroid cartilage in 15% of cases and below the level of thyroid cartilage in 5% of cases.

**Period and degree of suspension:**

If the period of the suspension of the body is more the ligature mark is very likely to be prominent and have parchment like pattern. In cases of complete hanging the ligature mark is more prominent than the case of partial hanging

If the period of the suspension of the body is less the ligature mark is very likely to be less prominent. When the hanging is from the low point of suspension, the ligature mark may have a horizontal course at the level of thyroid cartilage with increased findings of venous congestion.

**Slipping of the ligature:**

The slipping of the ligature may prevent the formation of the more prominent ligature mark but may produce a wider ligature mark or abrasion due to frictional displacement of the ligature material

**Weight of the body:**

The ligature mark is more prominent if the weight of the body is more and vice versa

**Ligature mark may not be well pronounced**

1. If the ligature material used is soft and broad
2. If any material like beard, clothing intervenes between the skin and the ligature material
3. If the point of suspension is low

## **INTERNAL FINDINGS:**

The internal findings in the post-mortem of cases of death due to hanging carries a significant importance as many artefacts need to be differentiated from the normal neck findings in the hanging so that strangulation is ruled out as a cause of death.

Schrader in 1940 recommended that the neck dissection has to be done at last in cases of hanging after removing the brain and the heart so that seepage of blood from the neck vessels is minimal while examining neck in the postmortem of cases of hanging. Prinsloo and Gordon artefacts are more common if the dissection of the neck is not done atleast in cases of hanging.

As a rule there should not be any bruising in the subcutaneous tissue, muscles of the neck in cases of hanging to differentiate it from the strangulation. The subcutaneous tissue under the ligature mark is very dry, white and glistening if the body is suspended for a long time. There may be presence of petechial hemorrhages in the adjacent tissues above and below the ligature mark.

Muscle fibres of the platysma and sternocleidomastoid (5- 10%) gets ruptured in cases of long drops and in cases of complete hanging.

Hemorrhages in the strap muscles may be present in about 25 % cases if the force is considerable.

There may be presence of tears in the intimal layers of the carotid arteries (5–10%) usually around the region of the carotid sinuses with extravasation of the blood in cases of death due to hanging with long drop

According to Gordon et al, histopathological examination of the skin showing ligature mark may show tissue reaction which will be seen after a few hours.

Fracture of the thyroid cartilages, cricoid cartilage and trachea are uncommon in cases of death due to hanging. Fracture of thyroid cartilage can occur in 40% of deaths due to hanging above the age of 40 years.

Fracture of hyoid bone is also uncommon in cases of death due to hanging. Incidence of Fracture of the hyoid bone in hanging varies in different studies from 0-60%. Usually the average is 15-20%. Fractures of the hyoid bone are rare below 40 years due to the elasticity of the cartilages and the mobility of the joints. Fracture of the hyoid bone usually occurs in the superior horns at the junction of inner two thirds and outer one third.

Fracture of hyoid bone is divided into three types. They are

1. Inward compression fractures most common in Throttling

2. Anteroposterior compression fractures most common in hanging
3. Traction or tug or avulsion fracture

In cases of hanging the hyoid bone is forced directly backwards leading to greater divergence of the superior horns of the hyoid bone resulting in the fracture and outward displacement of the posterior segment. In these type of fracture the periosteum is torn on the inner side so that the fragment moves easily outwards and the inward movement is possible only upto normal position. When the pressure is more the fragment detaches from the main hyoid bone and should be found out during the postmortem examination

Usually the hyoid bone fracture is unilateral but can also occur bilaterally. In some cases of bilateral fracture one side may have an inward compression fracture and the other may show an outward fracture. This is due to impingement of the posterior end of the hyoid bone getting struck against a bony ridge or a vertebra.<sup>48</sup>

### **STRANGULATION:**

Strangulation is a form of asphyxial death by neck compression which can be effected by the following ways:-

- Application of ligature as in Ligature Strangulation
- Application of human hands as in Manual Strangulation
- Any other means – stranglehold, foot or by some solid substance

Strangulation is mainly classified based on

A. Material used:

1. Ligature strangulation
2. Manual strangulation

B. Manner of strangulation:

1. Suicidal strangulation
2. Homicidal strangulation
3. Accidental strangulation

### **Ligature Strangulation:**

Asphyxia produced by constriction of the neck by a ligature without suspension of the body is called as Ligature Strangulation.

### **Manual strangulation:**

Asphyxia produced by the compression of the neck by human hands is called as Manual Strangulation or Throttling

**Suicidal strangulation:**

Suicide by strangulation is rare but possible. The signs of struggle and resistance will be absent apart from the absence of injuries to the deeper structures of the neck being insignificant. The signs of venous congestion are markedly seen and the ligature is found in situ. Suicidal strangulation can happen in the following ways.<sup>2,3</sup>

- Application of the ligature once or many times and finally tying the free ends
- Application of ligature by tourniquet mechanism i.e., applying the ligature only once in the neck following which a small piece of a rod or stick is passed through the ligature and twisted as a lever. After the consciousness is lost, the stick gets struck under angle of jaw thus maintaining the compression
- Application of a running noose to the neck and passing the free end several times around the right hand thereby strangulating wherein weight of the hand and forearm acts as a constricting force
- Application of a running noose and attaching a weight to the free ends of the ligature material<sup>2,3</sup>



**Homicidal strangulation:**

Strangulation is a common form of murder and strangulation is always assumed to be homicidal until proved otherwise. Injuries to the neck structures are more severe and extensive in cases of homicidal strangulation. Evidence of signs of struggle is common unless the victim is child or incapacitated by drugs or alcohol. Also in old age, females there may be less signs of struggle.

Many of the victims may be adult women and frequently strangulation may be associated with sexual assault. Usually there is a single turn of ligature and if there is more than one ligature mark homicide is almost certain. Fingernail marks may be seen if victims tries to resist the ligature or by application of hands by assailant in manual strangulation. The signs of venous congestion are markedly seen in cases of strangulation noted by subconjunctival hemorrhages in the eyes, intense cyanosis of the lips, nose and ear bleeding, marked congestion of the parts above the neck compression.<sup>2,3</sup>

**Accidental strangulation:**

Accidental strangulation is very rare and can occur in some circumstances

- Cord entanglement of the foetus before or during the process of birth
- Strangulation of children while playing<sup>2,3</sup>
- Persons under the influence of alcohol, epileptics and old individuals fall into a situation where they can't get out and die of strangulation
- Workers getting accidentally strangled by a clothing caught in a machinery
- Accidental throttling may occur by sudden application of pressure over neck of other person by hands though as a joke or as a symbol of affection

## **POSTMORTEM FINDINGS IN LIGATURE STRANGULATION:**

### **EXTERNAL FINDINGS:**

The asphyxial findings in strangulation will be more prominent more than hanging. The face may be swollen with petechial hemorrhages over the eyelids, face, forehead and scalp. The eyes are fully suffused and bulged out with dilated pupils. The tongue is swollen, protruding and caught between the teeth. Frothy fluid may be seen exuding from the mouth and the nostrils. There may be passage of urine or faeces or semen.

The ligature material used in ligature strangulation leaves a ligature mark whose depth is inversely proportional to the width of the constricting material. If a material whose width is smaller like rope, twines, wires, etc are used it produces a deep ligature mark. If a broad material like saree, dhoti, thupattas, etc is used it produces shallow ligature mark.<sup>2,3</sup>

Usually the ligature mark is yellowish or yellowish brown in colour completely encircling the neck at the level or below the thyroid cartilage. Sometimes the mark may be absent on the back due to increased musculature in the back. Homicidal ligature strangulation may have a U shaped ligature mark due to the attacking of the victim from the back by the assailant.<sup>62</sup>

The ligature mark produced depends on the material used for ligature strangulation. The pattern of the ligature mark can be seen well with the help of oblique lighting and magnifying glass. The ligature material can be compared with the ligature mark if its available during the postmortem

Occasionally there may be more than one ligature mark due to more than one turns of the ligature material around the neck. The ligature mark will be more marked depending on the duration and period of constriction of the ligature material around the neck.<sup>2,3</sup>

The ligature mark may be absent if any material like clothing, hair, victim's fingers, etc intervenes between neck and ligature material. There may be presence of fingernail abrasions caused either by victim or assailant, congestion of the face, petechial hemorrhages around the ligature mark.

### **INTERNAL FINDINGS:**

On dissection of the neck the presence of bruising of subcutaneous tissues and the neck muscles are the hallmark of ligature strangulation which helps in differentiating them from hanging. Bruising may be present even if the ligature mark is not present due to incomplete pressure by the ligature material.

Injuries to the blood vessels are rare in ligature strangulation. Injury to the hyoid bone is also rare in cases of ligature strangulation as compared to hanging since the level of compression is most commonly below the hyoid bone. But anteroposterior fracture may appear if a broad ligature is used or if the level of compression is at the level of hyoid. There may be presence of petechial hemorrhages in the muscles of the neck <sup>47</sup>

Lungs may show petechial hemorrhages also called as Tardieu spots along with the presence of emphysematous bulla at occasional places. All the other visceral organs may show congestion. When death occurs due to vagal inhibition, the asphyxial signs may be minimal.

## **POSTMORTEM FINDINGS IN MANUAL STRANGULATION:**

The postmortem findings in cases of death due to manual strangulation can be grouped into

- Cutaneous abrasions
- Cutaneous bruising
- Bruising into the deep structures of the neck
- Injuries to the hyoid bone<sup>2</sup>

### **Cutaneous abrasions:**

Irregular or crescentic abrasions are usually present in the neck which may correspond to assailant's nails. These nailmark abrasions depend on the length and contour of the nails. If the constricting hand is gloved these abrasions may be absent. If the nails are projecting typical nail mark abrasions are produced. In some cases the nail mark abrasions will be produced by the victims nails as the victim tries to defend of from the assailant.<sup>2,3</sup>

### **Cutaneous bruising:**

Bruising in the neck is produced by the rupture of cutaneous vessels as pressure is exerted upon the neck. From the configuration, location, number of surface injuries it is possible to delineate which hand was used

during manual strangulation. This becomes difficult when extensive subcutaneous bruising is present in the neck <sup>2,3</sup>

### **Bruising into the deep structures of the neck:**

Bruising in the deep muscles of the neck is due to direct pressure applied over the neck. There may be bruising of the mucosal surfaces of the pharynx, larynx and epiglottis. Bruising of the deep structures of the neck may be present even if the skin does not show any injuries.<sup>47</sup>

Fracture of the thyroid cartilage is more common in manual strangulation. Although the fracture is more common in old individuals it is also more common in teenagers too. Fracture of the body of the thyroid cartilage is rare. Fracture of the cricoid cartilage is also uncommon but if it occurs it may be due to direct pressure over the spine.

### **Injuries to the hyoid bone:**

Inward compression fractures of the hyoid bone is most commonly seen in Throttling where the main force is inward compressing action of the hyoid bone by the fingers. The fingers squeeze the greater horn towards each other and the periosteum is torn outside so that the posterior fractured segment moves inwards easily and moves up to the normal position outwards.

There must be a surrounding soft tissue bruising to differentiate the fracture into antemortem from postmortem. The fractured hyoid bone can be preserved along with the soft tissues for any further investigations.

## **CAUSES OF DEATH IN BY COMPRESSION OF NECK**

As commonly described Asphyxia is not the only cause of death in cases of death due to neck compression. The closure of airway due to neck compression is not only the essential element in hanging as it was described a case report by Reineboth in 1985 where a case of suicide by hanging who had undergone tracheostomy for carcinoma larynx. In that case report the ligature was way above the tracheostomy site and lead to the identification of various factors causing death in neck compression. The various factors causing the death of the individual in neck compression are listed below. They are

- a) Asphyxia due to compression of the airway
- b) Venous congestion
- c) Combined effects of asphyxia and venous congestion
- d) Cerebral anaemia
- e) Reflex vagal inhibition
- f) Fracture or Dislocation of the Cervical Vertebra<sup>65</sup>

**Asphyxia due to compression of the airway:**

Asphyxia in neck compression occurs mainly due to the constriction of the laryngeal and tracheal lumina by the constricting force of the ligature material and partly due to the forcing up of the root of the tongue against the posterior wall of the pharynx with folding of the epiglottis to block the laryngeal opening.

The laryngeal cartilages are soft and yielding so that complete closure of the airway is still inconclusive. If air entry is completely blocked death may occur rapidly with marked asphyxial signs. Brouardel suggested that a force of 15 kg is required to completely block the trachea.<sup>3</sup>

**Venous congestion:**

Jugular venous system is most superficial structures in the neck than the deep seated carotid arteries which are protected by the sternocleidomastoid muscles on either side. If the knot is below the chin the jugular venous system is blocked and the arterial flow may continue leading to increased venous congestion in the area above the ligature mark. The jugular venous system is most commonly blocked with a less force of 2 kg itself.<sup>3</sup>



**Combined effects of asphyxia and venous congestion:**

This is the most common mechanism of death due to neck compression usually involving both the occlusion of Jugular venous system and the laryngeal and tracheal cartilages.

**Cerebral anaemia:**

Usually the carotid and vertebral arteries are protected well by the neck structures the force to occlude them has to be more. Ligature producing a force 4 to 5 kg occludes carotid arteries and a force of 20 kg is needed to occlude the vertebral arteries is needed since vertebral arteries are well deep seated and pass in the vertebral canal. Pressure on the large arteries produces cerebral anaemia and immediate coma if the pressure is sustained for 10 to 15 seconds. If the pressure is immediately released consciousness is regained in another 10 seconds. It most commonly occurs if the knot is situated in the nape of the neck since both arterial and venous flow is obstructed by the pressure on the noose on both sides of the neck<sup>3</sup>

**Reflex vagal inhibition:**

Pressure on the carotid sinuses situated in the sides of the neck at the level of upper border of thyroid cartilage may cause death in neck compression by reflex vagal inhibition on heart producing bradycardia. Carotid sinuses are dilated part of the walls of the carotid artery which are

supplied by numerous endings of glossopharyngeal nerves. On stimulation of these nerve endings on the carotid sinuses signals are passed on to the vagal nucleus in the brain stem which in turn sends signals along the vagus nerve supplying the heart causing bradycardia and death.<sup>2</sup>

### **Fracture or Dislocation of the Cervical Vertebra**

Fracture or dislocation of cervical vertebra most commonly occurs in Judicial hanging so that death is painless. Fracture or dislocation of cervical vertebra causes severing of the upper cervical spinal cord leading to unconsciousness and death.<sup>65</sup>

### **OTHER FORMS OF NECK COMPRESSION:**

The other forms of neck compression causing asphyxia are

1. Mugging
2. Garotting
3. Bansdola
4. Palmar strangulation

### **MUGGING:**

Mugging is a form of neck compression causing asphyxia where the pressure around the neck is given by the bend of the elbow. The victim is attacked usually from the behind with the bend of the elbow coming across

the neck causing the front and sides of the larynx to get compressed. Death may occur due to asphyxia or by reflex cardiac arrest.

### **GAROTTING:**

Garotting is a form of neck compression causing asphyxia where a thin string or a wire is put around the victim's neck from the back. The string is rapidly tightened with the help of sticks tied to the free ends of the string so that constriction of the neck is strong enough to cause death. This method was used to be the official method of execution in Spain where a device was formulated in the name of Spanish Windlass

### **BANSDOLA:**

Bansdola is a form of neck compression causing asphyxia where the neck is compressed with two bamboo sticks one in the front and the other at the back of the neck. Sometimes only one stick is placed in front of the victim's neck and the assailant exerts pressure on the neck by standing over the stick.

### **PALMAR STRANGULATION:**

Palmar strangulation is a form of neck compression causing asphyxia where one hand is placed horizontally across the mouth and nostrils and placing the other palm on top of it at right angles pressing the neck.

# **MATERIALS AND METHODS**

## **MATERIALS AND METHODS**

This prospective study was conducted in the Institute of Forensic Medicine, Madras Medical College, Chennai-3 for a period of 6 months.

This study quantitatively analyzed the heart blood from the left ventricle for Thyroglobulin levels, in cases of neck compression subjected for autopsy within 72 hours after death, by a highly sensitive and rapid Chemiluminescence Immunoassay (CLIA) analyser and correlated with the histopathological findings of Thyroid gland taken during the autopsy. The study sample consisted of 25 heart blood samples taken from cases of neck compression like hanging, manual strangulation, Ligature strangulation. A control sample (n = 25) consisting of deaths due to Road traffic accidents, Poisoning and natural causes like myocardial infarction, stroke, tuberculosis etc. were taken. Before getting into the study, Ethical clearance was obtained from the Institutional Ethical committee (IEC).

In dead bodies with history of neck compression subjected for autopsy, after making a longitudinal incision on the skin dissecting out the skin, subcutaneous tissue, fascia and muscle with a BP handle scalpel blade, reflecting out the skin together with the muscles, cutting the ribs at the costochondral junction along with the sternoclavicular joint disarticulating it and the sternum lifted up, dissected out exposing the thoracic cavity and the

heart, blood was withdrawn from the left chamber of the heart with a 21G sterile syringe with needle and immediately transferred to a sterile sampling test tube, corked with the stopper and sent for analysis at a private lab. Serum Thyroglobulin levels in heart blood serum was measured using Chemiluminescence immunoassay Analyser.

As routinely practiced in the autopsies of death due to neck compression to dissect the neck last after opening all the cavities, the neck is examined externally for the ligature mark which may not be found if a broad soft ligature material used or if there is any interference between ligature material and the skin. The ligature mark is measured and the distances from the anatomical points are also noted.<sup>66</sup>

Then the skin is reflected by making a incision from symphysis menti to suprasternal notch. The base of the ligature mark is noted for its dryness, paleness. Then the subcutaneous tissue is noted for any bruises. The sternocleidomastoid muscle is cut from its origin and reflected upwards. The Infrahyoid muscles are noted for bruises. Sternohyoid and sternothyroid muscles are cut from its origin and reflected upwards. The thyroid is dissected out carefully and sent for Histopathological examination. The Laryngeal cartilages and the Hyoid bone are noted for any kind of fracture.<sup>67</sup>

### **Chemiluminescence Immunoassay:**

- Chemiluminescence Immunoassay (CLIA) provides a sensitive, fully automated immunological technique
- The blood obtained from the autopsy is centrifuged to separate the serum and then provided in the Chemiluminescence Immunoassay Immulite analyser.<sup>68,69</sup>
- The Principle of the test is that it measures the intensity of light emitted when the complex of antigen in the deceased sample and the enzyme linked antibody reacts with chemiluminescent molecule (such as luminol) producing a weak signal.
- The enzyme component then provides signal amplification.
- Chemi – Luminescence Immuno Assay Immulite Analyser is based on four monoclonal antibodies and which produces results in 40 min.
- Immulite Analyser has Analytical sensitivity of 0.01 ng /ml & Functional sensitivity 0.1 ng /ml.
- Up to 200 tests per hour in batch can be done in Immulite Analyser<sup>72</sup>

**Fig.7 showing Immulite Analyser**



**Subject Selection:**

The prospective study was conducted on cases coming for Medico Legal autopsy to the Institute of Forensic Medicine, Madras Medical College, Chennai-3.

**Inclusion Criteria:**

All dead bodies with history of Neck Compression subjected for autopsy within 72 hours of death



**Exclusion Criteria:**

- All dead bodies with history of Neck Compression subjected for autopsy after 72 hours of death.
- All dead bodies subjected for autopsy diagnosed to have Thyroid Cancer, Thyroid surgeries, Treatment for any Thyroid Diseases

There are various factors which affect the outcome of this study. Post mortem interval is one of the factors which strongly affect the level of Serum Thyroglobulin<sup>70, 71</sup>. In the present study most of the cases are brought dead to casualty and the exact time of death is not known to either the investigating officers or the relatives. Therefore the Postmortem interval given in the Master chart is only the approximate time since death derived from the information furnished by the investigating officer. In general greater the postmortem interval lower will be the postmortem levels of serum thyroglobulin levels as the half life is 65 hours so that there may be false negative results.

False positive results may be obtained if the deceased was suffering from Thyroid carcinoma and Hashimoto's Thyroiditis.

This can be excluded if the thyroid of the deceased is sent for Histopathological examination to rule out Thyroid carcinoma and Hashimoto's Thyroiditis.<sup>73, 74</sup>

# **ANALYSIS AND RESULTS**

## ANALYSIS AND RESULTS

### STUDY GROUP

Total number of Cases with History of Neck compression (Study group) = 25

It consists of the following cases

Total number of Cases with History of Hanging = 21

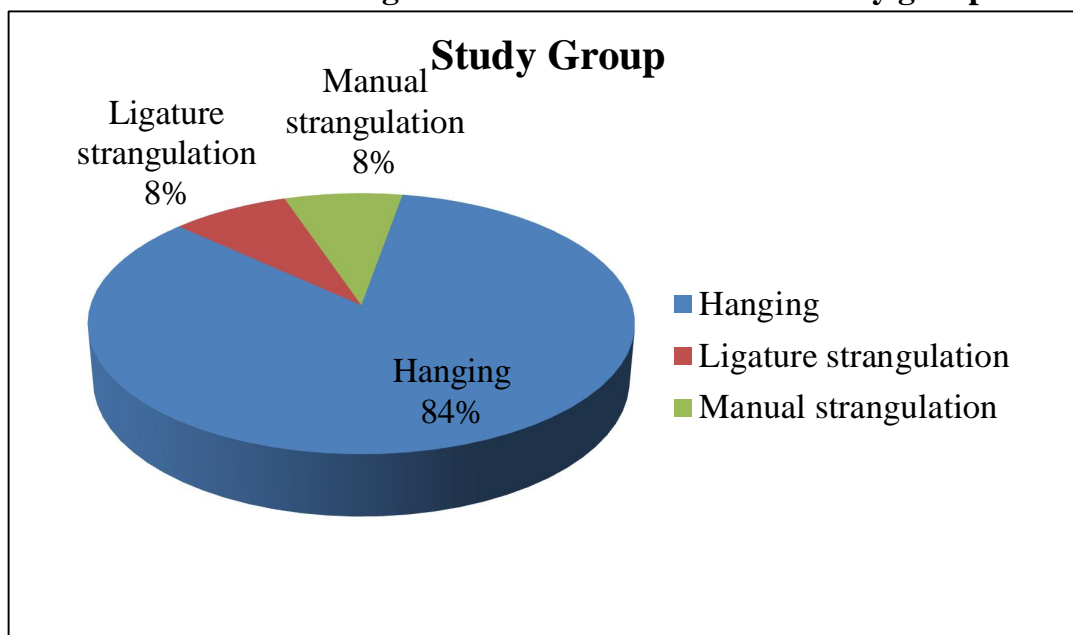
Total number of Cases with History of Ligature strangulation = 2

Total number of Cases with History of Manual Strangulation = 2

**Table no.2 illustrating number of cases in study group**

Study group	Number of cases	Percentage
Hanging	21	84 %
Ligature strangulation	2	8 %
Manual strangulation	2	8 %
Total	N = 25	100 %

**Chart no. 1 showing the number of cases in the study group**



## CONTROL GROUP

Total number of cases in control group = 25

It consists of the following cases

Total number of cases died due to Natural cause = 5

Total number of cases died due to Poisoning = 5

Total number of cases died due to Road Traffic Accident = 5

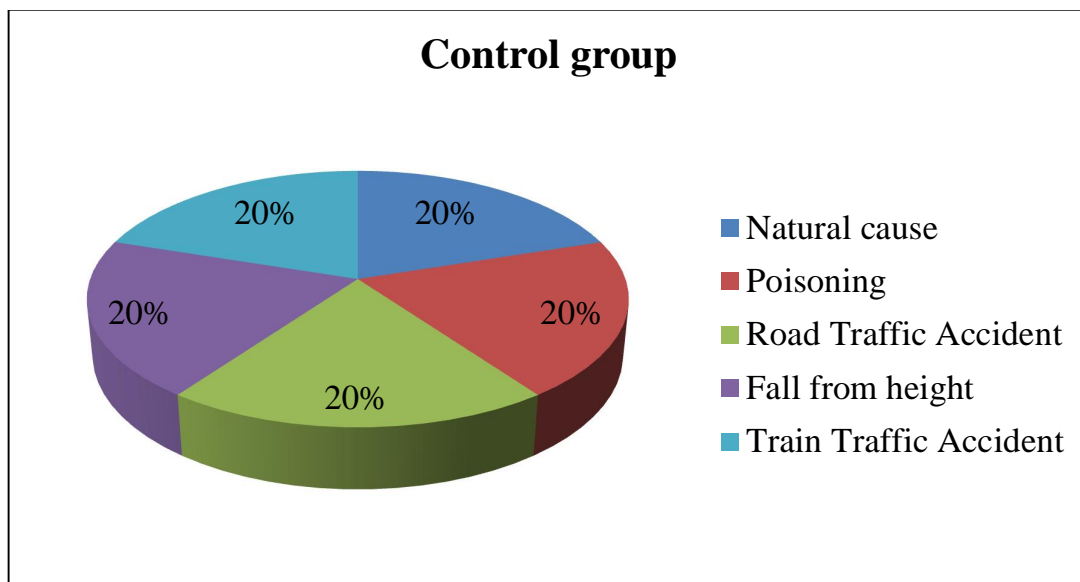
Total number of cases died due to fall from height = 5

Total number of cases died due to Train Traffic Accident = 5

**Table No.3 illustrating the number of cases in control group**

Control group	Number of cases	Percentage
Natural cause	5	20 %
Poisoning	5	20 %
Road Traffic Accident	5	20%
Fall from height	5	20 %
Train Traffic Accident	5	20 %
Total	N = 25	100 %

**Chart no. 2 showing the number of cases in the control group**



## SEX DISTRIBUTION IN STUDY GROUP

Total number of Cases with History of Neck

compression (Study group) = 25

Total number of male = 18

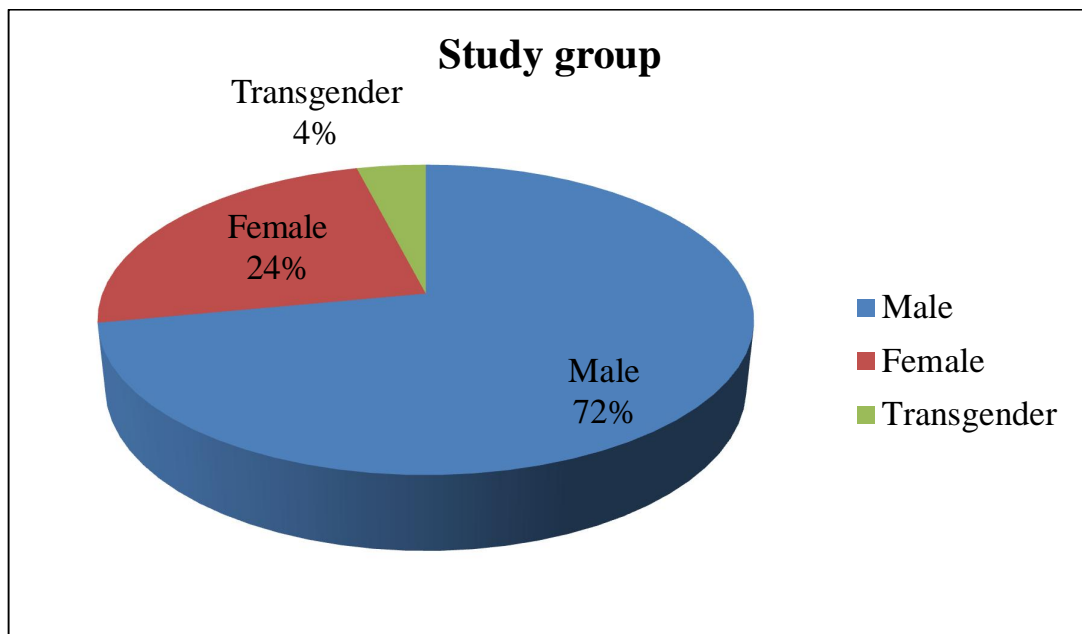
Total number of female = 6

Total number of Transgender = 1

**Table No.4 illustrating the sex distribution of cases in study group**

Study group	Number of cases	Percentage
Male	18	72 %
Female	6	24 %
Transgender	1	4 %
Total	N = 25	100 %

**Chart no. 3 showing sex distribution of cases in the study group**



### SEX DISTRIBUTION IN CONTROL GROUP

Total number of Cases in control group = 25

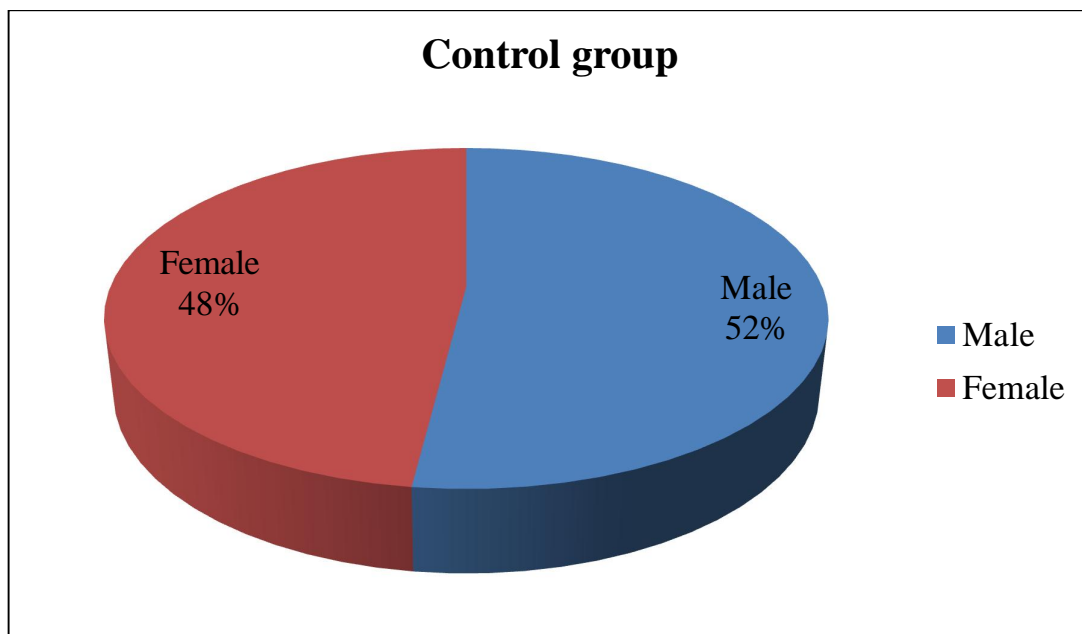
Total number of male = 13

Total number of female = 12

**Table No.5 illustrating the sex distribution of cases in control group**

Control group	Number of cases	Percentage
Males	13	52 %
Female	12	48 %
Total	N = 25	100 %

**Chart no. 4 showing sex distribution of cases in the control group**



### AGE DISTRIBUTION IN STUDY GROUP

Total number of Cases with History of Neck  
compression (Study group) = 25

Total number of Case in age group 0 – 20 years = 2

Total number of cases in age group 21 – 40 years = 18

Total number of cases in age group 41 – 60 years = 4

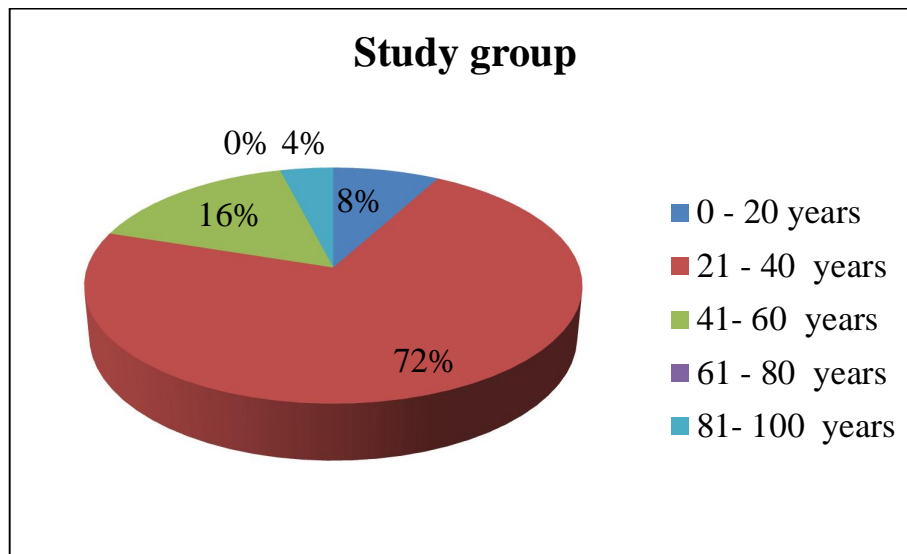
Total number of cases in age group 61 – 80 years = 0

Total number of cases in age group 81 – 100 years = 1

**Table No.6 illustrating the age distribution of cases in study group**

Age distribution in Study group	Number of cases	Percentage
0 - 20 years	2	8 %
21 – 40 years	18	72 %
41- 60 years	4	16 %
61 - 80 years	0	0 %
81- 100 years	1	4 %
Total	N = 25	100 %

**Chart no. 5 showing age distribution of cases in the study group**



### AGE DISTRIBUTION IN CONTROL GROUP

Total number of Cases in control group = 25

Total number of Case in age group 0 – 20 years = 2

Total number of cases in age group 21 – 40 years = 9

Total number of cases in age group 41 – 60 years = 12

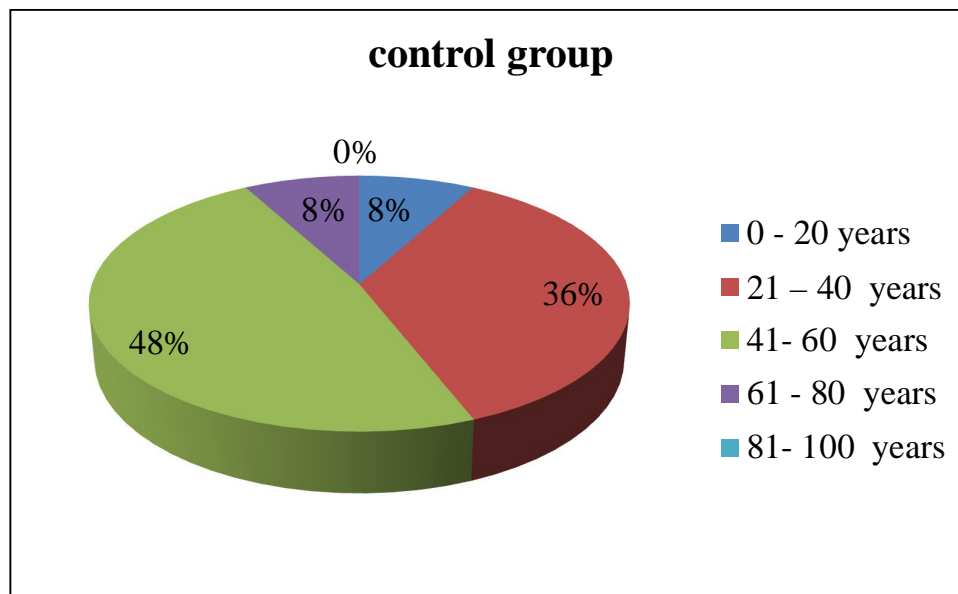
Total number of cases in age group 61 – 80 years = 2

Total number of cases in age group 81 – 100 years = 0

**Table No.7 illustrating the sex distribution of cases in control group**

Age distribution in Study group	Number of cases	Percentage
0 - 20 years	2	8 %
21 – 40 years	9	36 %
41- 60 years	12	48 %
61 - 80 years	2	8 %
81- 100 years	0	0 %
Total	N = 25	100 %

**Chart no. 6 showing age distribution of cases in the control group**





**SERUM THYROGLOBULIN LEVELS AND HISTO  
PATHOLOGICAL FINDINGS IN THE STUDY GROUP**

**Table No.8 illustrating the cases in study group**

<b>S. No</b>	<b>P.M. No.</b>	<b>Cause of death</b>	<b>Serum Thyroglobulin level</b>	<b>Histo pathological findings</b>	<b>Inference</b>
1.	805/14	Hanging	245.4	Normal	POSITIVE
2.	867/14	Hanging	198.2	Normal	POSITIVE
3.	888/14	Hanging	367.2	Normal	POSITIVE
4.	920/14	Hanging	193.2	Normal	POSITIVE
5.	1053/14	Manual strangulation	2565.7	Normal	POSITIVE
6.	1066/14	Hanging	467.2	Normal	POSITIVE
7.	1106/14	Hanging	241.7	Normal	POSITIVE
8.	1112/14	Hanging	1780.1	Papillary carcinoma	FALSE POSITIVE
9.	1122/14	Hanging	289.3	Normal	POSITIVE
10.	1173/14	Manual strangulation	5642.9	Normal	POSITIVE
11.	1178/14	Ligature strangulation	4563.6	Normal	POSITIVE
12.	1181/14	Hanging	536.8	Normal	POSITIVE
13.	1213/14	Hanging	1342.3	Hashimoto's thyroiditis	FALSE POSITIVE
14.	1221/14	Hanging	187.3	Normal	POSITIVE
15.	1234/14	Hanging	126.3	Normal	POSITIVE
16.	1244/14	Ligature strangulation	6754.1	Normal	POSITIVE
17.	1248/14	Hanging	66.2	Normal	POSITIVE

18.	1292/14	Hanging	347.3	Normal	POSITIVE
19.	1294/14	Hanging	298.5	Normal	POSITIVE
20.	1341/14	Hanging	201.3	Normal	POSITIVE
21.	1383/14	Hanging	53.9	Normal	POSITIVE
22.	1390/14	Hanging	267.8	Normal	POSITIVE
23.	1415/14	Hanging	341.7	Normal	POSITIVE
24.	1451/14	Hanging	276.5	Normal	POSITIVE
25.	1469/14	Hanging	186.2	Normal	POSITIVE

**Table no.9 showing correlation of Serum Thyroglobulin levels with Histopathological findings**

<b>Serum Thyroglobulin</b>	<b>Histopathology</b>		<b>Total</b>
	<b>Normal</b>	<b>Hashimotos's/Papillary carcinoma</b>	
Positive	23	2	23
Negative	0	0	2
<b>Total</b>	<b>23</b>	<b>2</b>	<b>25</b>

Total number of true positive cases in the study group = 23

Total number of false positive cases in the study group = 2

False positives in the study group are due to the presence of Hashimoto's Thyroiditis and Papillary carcinoma of thyroid of Histopathology of the thyroid.

### Calculation of Mean values in the Study group:

Total number of cases of Neck compression

including Hanging, Manual strangulation, = 25

Ligature Strangulation in the study group (n)

Sum of the Serum Thyroglobulin Levels in the study group = 27540.7 ng/ml

$$\begin{aligned} \text{Mean value of Serum} &= \frac{\text{Sum of the Serum Thyroglobulin}}{\text{Total number of cases of study}} \\ \text{Thyroglobulin Levels in Cases of} & \text{Levels of cases of study group} \\ \text{study group.} & \\ &= \frac{27540.7}{25} \\ &= 1101.6 \text{ ng/ml} \end{aligned}$$

Standard error of the mean : 367.4 ng/ml

Excluding the values of two false positive values in the study group, the true mean value of the Serum Thyroglobulin can be found out.

Sum of the Serum Thyroglobulin Levels of = 24418.3 ng/ml

the true positive cases in the study group

Total number of true positive cases in the study group = 23

$$\begin{aligned}
 \text{True Mean value of Serum Thyroglobulin Levels in Cases of study group.} &= \frac{\text{Sum of the Serum Thyroglobulin Levels of true positive cases of study group}}{\text{Total number of true positive cases of study group}} \\
 &= \frac{24418.3}{23} \\
 &= 1061.6 \text{ ng/ml}
 \end{aligned}$$

Standard error of the mean : 398.7 ng /ml

#### **Calculation of Mean value in Hanging:**

Total number of cases of Hanging = 21  
in the study group (n)

Sum of the Serum Thyroglobulin Levels in cases of Hanging = 8014.4ng/ml  
in the study group

$$\begin{aligned}
 \text{Mean value of Serum Thyroglobulin Levels in the Hanging cases of study group} &= \frac{\text{Sum of the Serum Thyroglobulin Levels in cases of Hanging in the study group}}{\text{Total number of cases of Hanging in study group}} \\
 &= \frac{8014.4 \text{ ng/ml}}{21} \\
 &= 381.6 \text{ ng/ml}
 \end{aligned}$$

Standard error of the mean : 90.5 ng /ml

Sum of the Serum Thyroglobulin Levels of = 4892 ng/ml

the true positive cases in the study group

Total number of true positive cases in the cases of Hanging

in study group = 19

True Mean value of Serum Thyroglobulin Levels in Cases of Hanging in the study group	=	Sum of the Serum Thyroglobulin Levels of true positive cases of Hanging in the study group
--	---	--

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Total number of true positive cases  
of Hanging in the study group

= 4892 ng/ml

19

= 257.4 ng/ml

Standard error of the mean : 28.03 ng /ml

### **Calculation of Mean value in Ligature strangulation:**

Total number of cases of Ligature strangulation = 2  
in the study group (n)

Sum of the Serum Thyroglobulin Levels in cases of = 9319.8 ng/ml

Ligature strangulation in the study group

$$\begin{aligned}
 \text{Mean value of Serum} &= \frac{\text{Sum of the Serum Thyroglobulin Levels of cases of Ligature strangulation in the study group}}{\text{Total number of cases of Ligature strangulation in the study group}} \\
 &= \frac{9319.8 \text{ ng/ml}}{2} \\
 &= 4659.9 \text{ ng/ml}
 \end{aligned}$$

Standard error of the mean : 2094.2 ng / ml

#### **Calculation of Mean value in Manual strangulation:**

Total number of cases of Manual strangulation in the study group (n) = 2

Sum of the Serum Thyroglobulin Levels in cases of Manual strangulation in the study group = 10206.5 ng/ml

$$\begin{aligned}
 \text{Mean value of Serum} &= \frac{\text{Sum of the Serum Thyroglobulin Levels of cases of Manual strangulation in the study group}}{\text{Total number of cases of Manual strangulation in the study group}}
 \end{aligned}$$

$$= \frac{10206.5 \text{ ng/ml}}{2}$$

2

$$= 5103.2 \text{ ng/ml}$$

Standard error of the mean : 539.6 ng / ml

### **COMPARISON OF MEAN VALUES IN HANGING, LIGATURE STRANGULATION, MANUAL STRANGULATION**

**Table No.10 illustrating the comparison of Serum Thyroglobulin levels  
in cases of Hanging, Manual strangulation and  
Ligature strangulation in the study group**

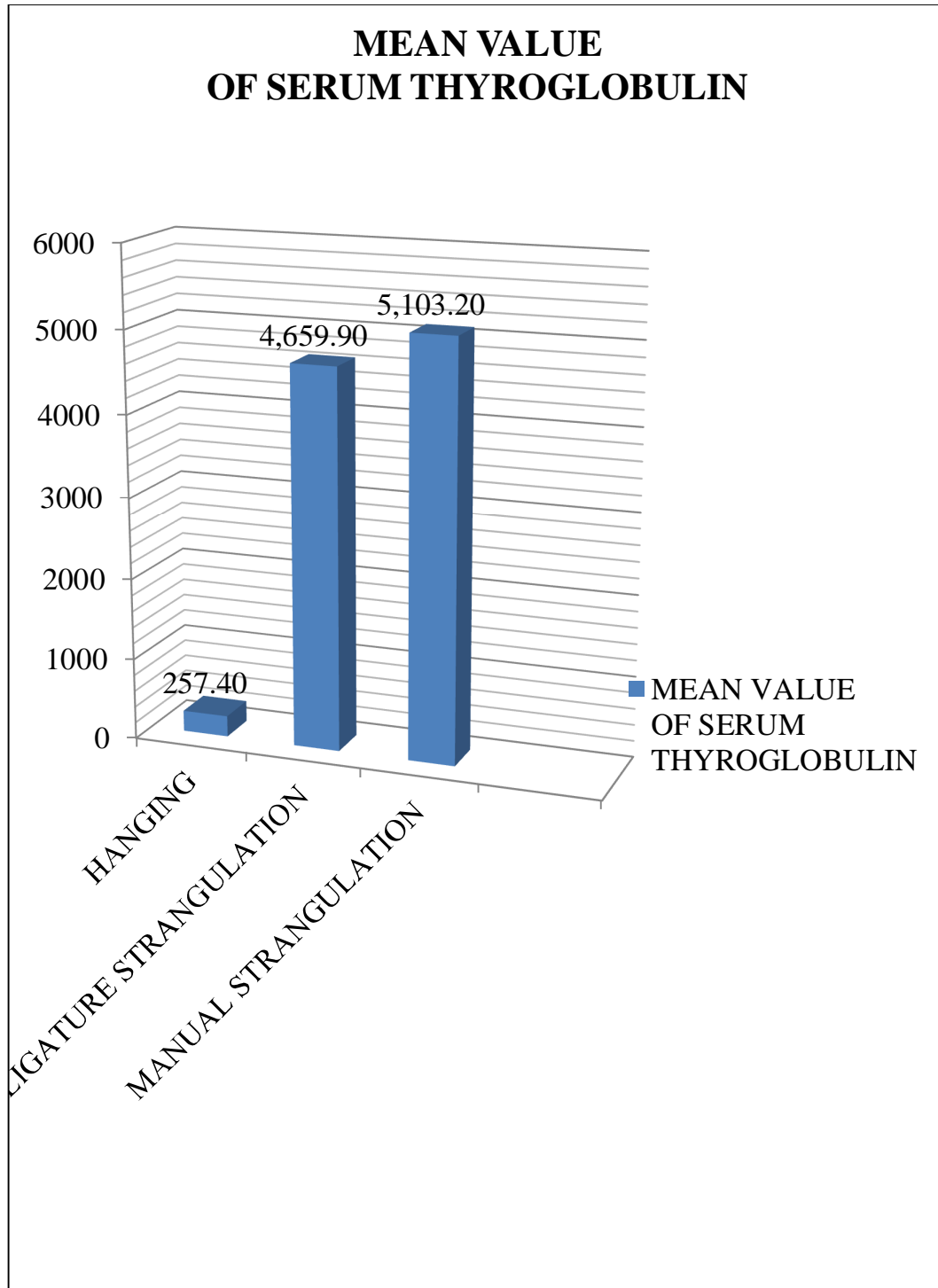
<b>TYPE OF NECK COMPRESION</b>	<b>NUMBER OF CASES</b>	<b>MEAN VALUE OF SERUM THYROGLOBULIN (ng/ml)</b>
<b>HANGING</b>	<b>19</b>	<b>257.4 ng/ml</b>
<b>LIGATURE STRANGULATION</b>	<b>2</b>	<b>4659.9 ng/ml</b>
<b>MANUAL STRANGULATION</b>	<b>2</b>	<b>5103.2 ng/ml</b>

Standard error of the mean in Hanging : 28.03 ng / ml

Standard error of the mean in Ligature strangulation : 539.6 ng / ml

Standard error of the mean in manual strangulation : 2094.2 ng / ml

**Chart no.7 showing the comparison of Serum Thyroglobulin levels in cases of Hanging, Manual strangulation and Ligature strangulation in the study group**





**SERUM THYROBLOBULIN LEVELS AND HISTO  
PATHOLOGICAL FINDINGS IN THE CONTROL GROUP**

**Table No.11 illustrating the cases in control group**

<b>S. No</b>	<b>P.M. No.</b>	<b>Cause of death</b>	<b>Serum Thyroglobulin level</b>	<b>Histo pathological findings</b>	<b>Inference</b>
1.	873/14	Natural Cause	26.6	Normal	Normal
2.	896/14	Natural Cause	1.5	Normal	Normal
3.	900/14	Natural Cause	3.1	Normal	Normal
4.	901/14	Natural Cause	23.3	Normal	Normal
5.	903/14	Natural Cause	23.1	Normal	Normal
6.	904/14	Poisoning	11.2	Normal	Normal
7.	905/14	Poisoning	34.6	Normal	Normal
8.	910/14	Poisoning	22.1	Normal	Normal
9.	912/14	Poisoning	14.4	Normal	Normal
10.	913/14	Poisoning	9.2	Normal	Normal
11.	914/14	RTA	35.8	Normal	Normal
12.	916/14	RTA	14.2	Normal	Normal
13.	926/14	RTA	34.3	Normal	Normal
14.	927/14	RTA	12.3	Normal	Normal
15.	931/14	RTA	34.4	Normal	Normal
16.	932/14	TTA	14.2	Normal	Normal

17.	933/14	TTA	34.4	Normal	Normal
18.	941/14	TTA	2.3	Normal	Normal
19.	962/14	TTA	49.1	Normal	Normal
20.	967/14	TTA	33.2	Normal	Normal
21.	970/14	Fall From Height	4.5	Normal	Normal
22.	977/14	Fall From Height	33.2	Normal	Normal
23.	978/14	Fall From Height	44.1	Normal	Normal
24.	980/14	Fall From Height	15.6	Normal	Normal
25.	990/14	Fall From Height	14.6	Normal	Normal

### Calculation of Mean values in the Control group:

Total number of cases of in the control group (n) = 25

Sum of the Serum Thyroglobulin Levels in the control group = 545.3 ng/ml

Mean value of Serum Thyroglobulin Levels in Cases of control group. = 
$$\frac{\text{Sum of the Serum Thyroglobulin Levels of cases of control group}}{\text{Total number of cases of control group}}$$

= 545.3

25

= 21.8 ng/ml

### **Ligature mark in study group**

Total number of cases in study group = 25

Total number of cases with marked ligature mark in study group = 14

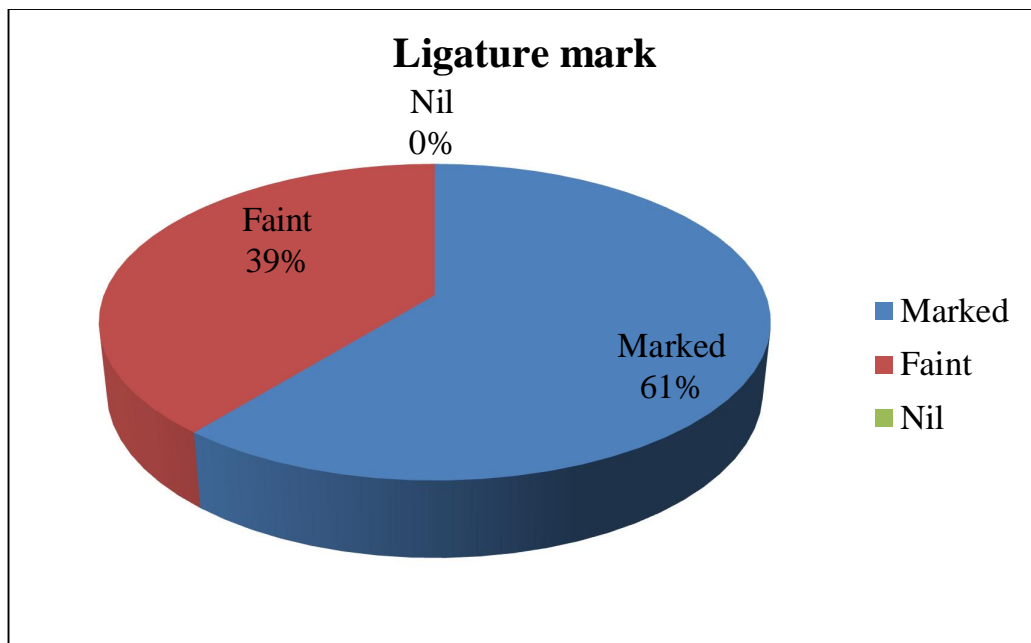
Total number of cases with faint ligature mark in study group = 9

Total number of cases with no ligature mark in study group = 2

**Table no.12 illustrating the ligature mark in cases of study group**

<b>Ligature mark</b>	<b>Number of cases</b>	<b>Percentage</b>
Marked	14	61 %
Faint	9	39 %
Nil	0	0 %
Total	N = 25	100 %

**Chart no.8 showing ligature mark used in the study group**



### Ligature material used in study group

Total number of cases in study group = 25

Total number of cases used nylon saree in study group = 11

Total number of cases used nylon rope in study group = 7

Total number of cases used thupatta in study group = 3

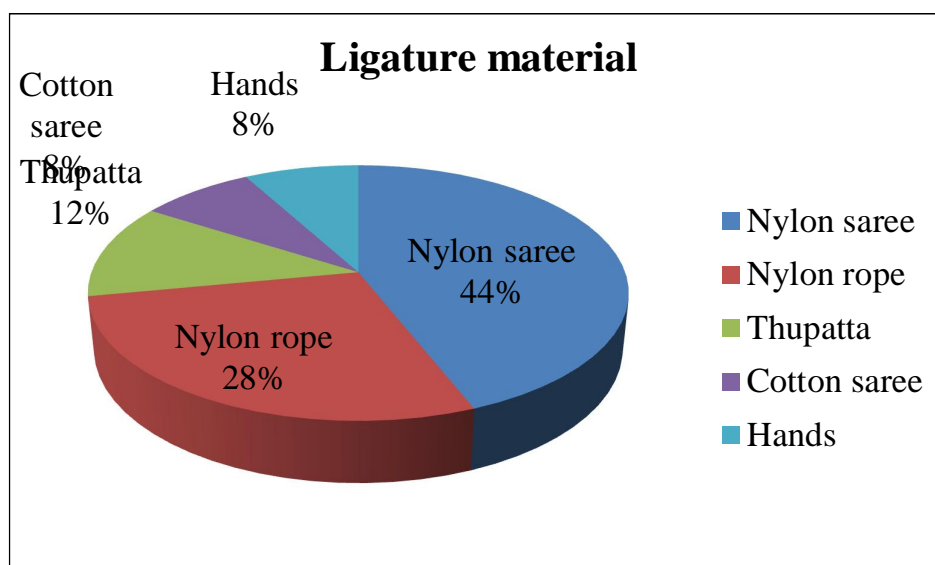
Total number of cases used cotton saree in study group = 2

Total number of cases used hands in study group = 2

**Table no.13 illustrating ligature material used in the study group**

Ligature material	Number of cases	Percentage
Nylon saree	11	44 %
Nylon rope	7	28 %
Thupatta	3	12
Cotton saree	2	8
Hands	2	8
Total	N = 25	100 %

**Chart no.9 showing ligature material used in the study group**



### Cyanosis in study group

Total number of cases in study group = 25

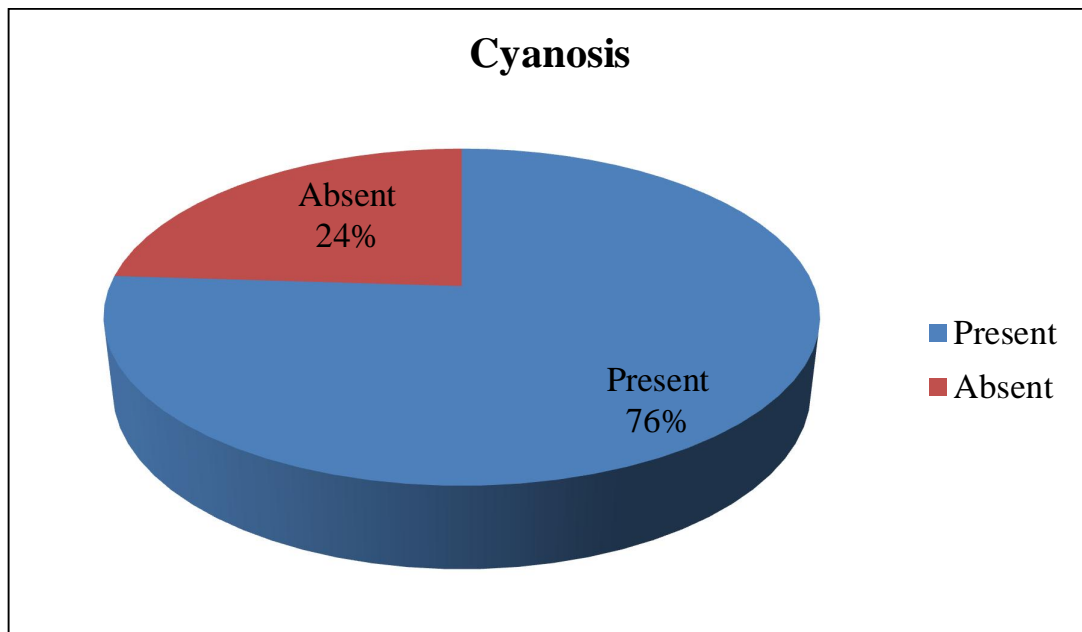
Total number of cases with cyanosis in study group = 19

Total number of cases without cyanosis in study group = 6

**Table No.14 illustrating the presence of cyanosis in cases of study group**

Cyanosis	Number of cases	Percentage
Present	19	76 %
Absent	6	24 %
Total	N = 25	100 %

**Chart no.10 showing cyanosis in the study group**



### **Petechial hemorrhages in study group**

Total number of cases in study group = 25

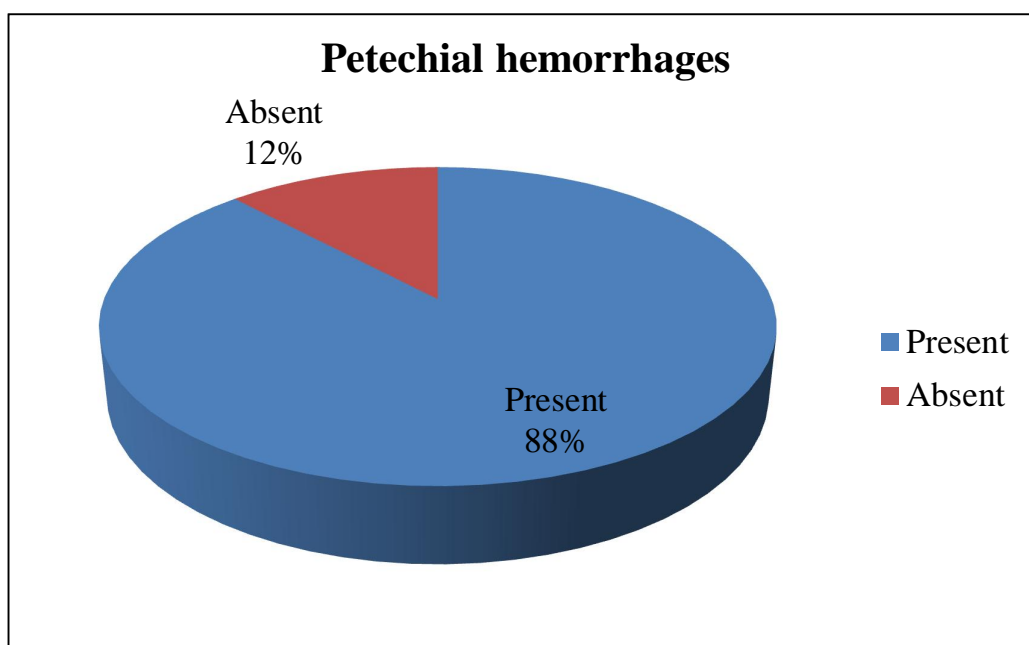
Total number of cases with Petechial hemorrhages in study group = 22

Total number of cases with Petechial hemorrhages in study group = 3

**Table No.15 illustrating the petechial hemorrhages in the study group**

<b>Petechial hemorrhages</b>	<b>Number of cases</b>	<b>Percentage</b>
Present	22	88 %
Absent	3	12 %
Total	N = 25	100 %

**Chart no.11 showing Petechial hemorrhages in the study group**



### **Congestion in study group**

Total number of cases in study group = 25

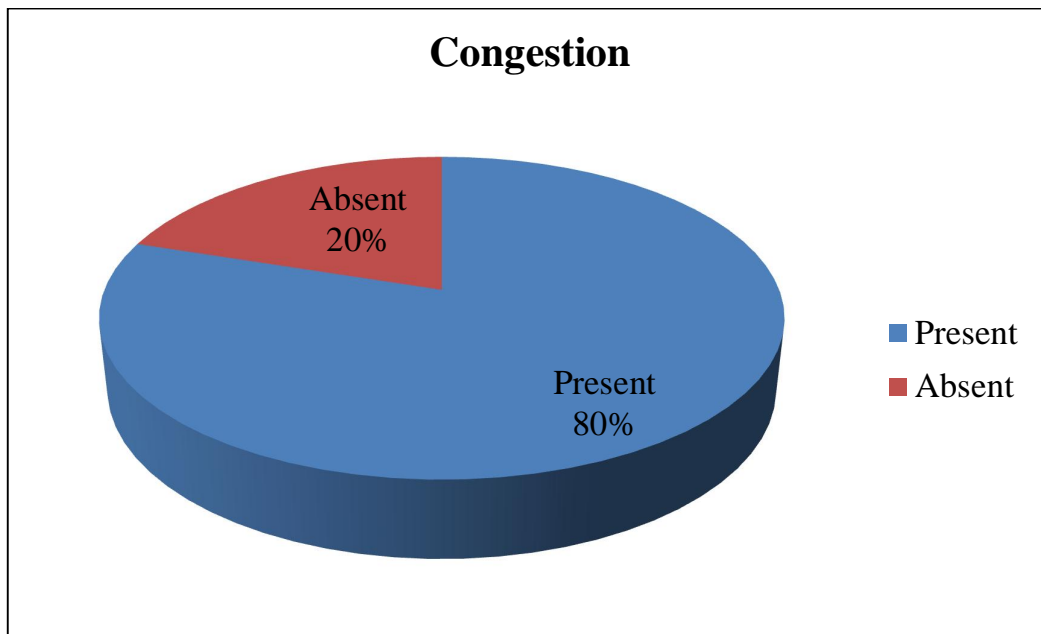
Total number of cases with Congestion in study group = 20

Total number of cases without Congestion in study group = 5

**Table No.16 illustrating the presence of Congestion in cases of study group**

<b>Congestion</b>	<b>Number of cases</b>	<b>Percentage</b>
Present	20	80 %
Absent	5	20 %
Total	N = 25	100 %

**Chart no.12 showing congestion in the study group**



### Fluidity of the blood in study group

Total number of cases in study group = 25

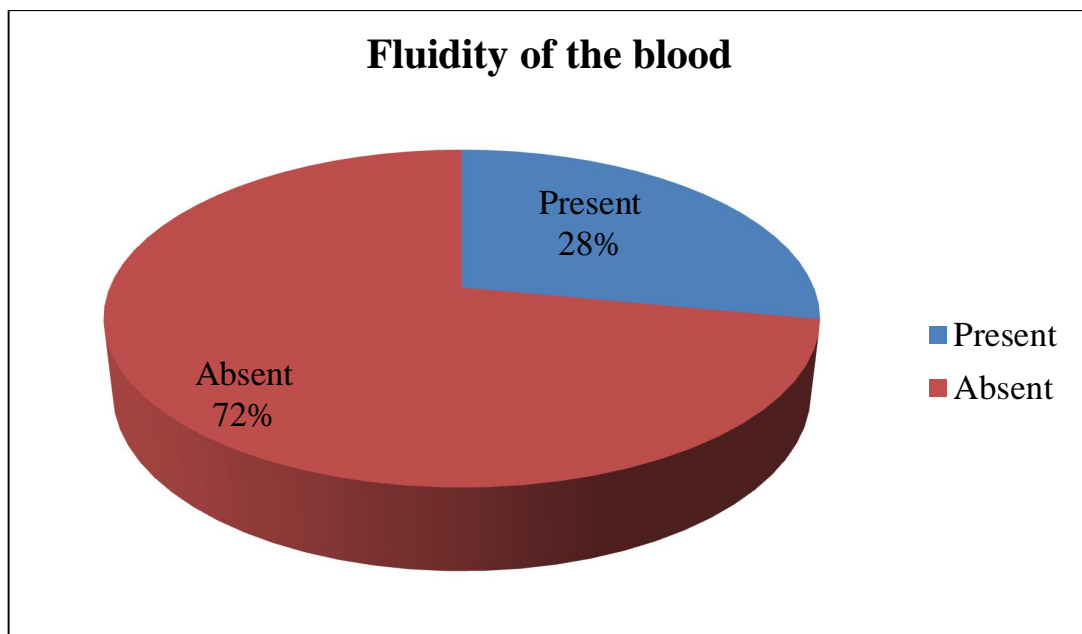
Total number of cases with Fluidity of the blood in study group = 7

Total number of cases without Fluidity of the blood in study group = 18

**Table No.17 illustrating the fluidity of the blood in the study group**

Fluidity of the blood	Number of cases	Percentage
Present	7	28 %
Absent	18	72 %
Total	N = 25	100 %

**Chart no.13 showing fluidity of the blood in the study group**





### Postmortem interval in study group

Total number of cases in study group = 25

Total number of cases done in 0 – 36 hours after death in study group = 16

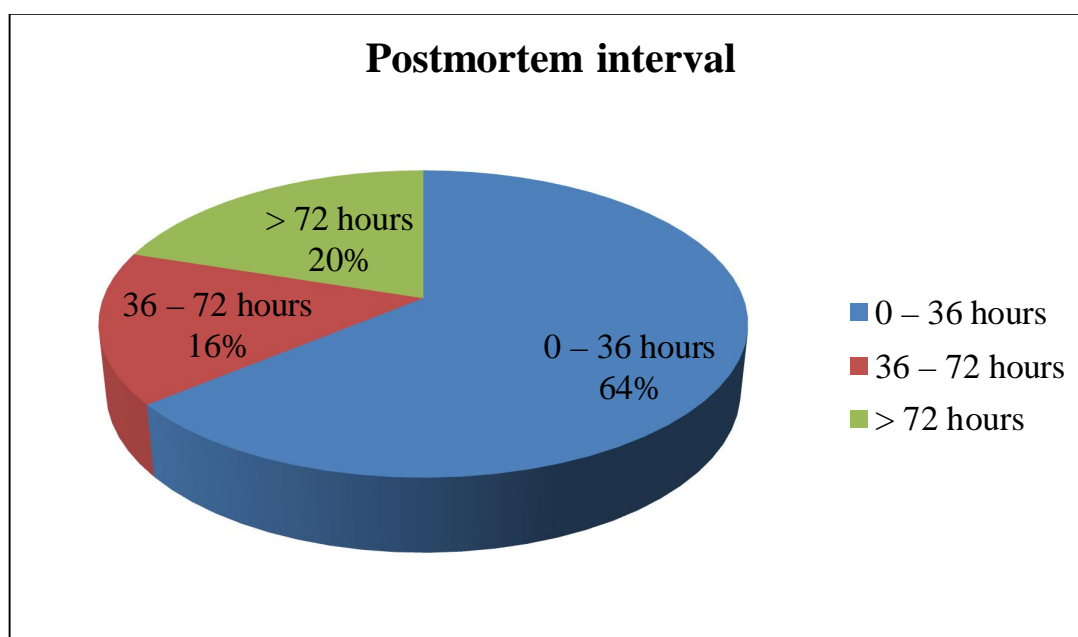
Total number of cases done in 36 – 72 hours after death in study group = 4

Total number of cases done after 72 hours after death in study = 5

**Table No.18 illustrating the postmortem interval in the study group**

Postmortem interval	Number of cases	Percentage
0 – 36 hours	16	64 %
36 – 72 hours	4	16 %
> 72 hours	5	20 %
Total	N = 25	100 %

**Chart no.14 showing postmortem interval in the study group**



## **RESULTS**

This is a prospective study conducted with the aim of establishing serum thyroglobulin as a marker to diagnose neck compression and to compare the levels of serum thyroglobulin between types of neck compression like hanging, ligature strangulation and manual strangulation. The other causes of the serum thyroglobulin levels are ruled out by Histopathological examination of the thyroid gland dissected out during autopsy.

The serum thyroglobulin is estimated from the post-mortem heart blood samples by chemiluminescence immunoassay with the help of Immulite analyser. Serum thyroglobulin is estimated in two groups. Each group consists of 25 cases.

The study group consists of 25 cases of death due to neck compression.

Out of the 25 cases, 21 cases belongs to death due to hanging (84 %), 2 cases of death due to ligature strangulation(8 %) and 2 cases of death due to manual strangulation(8 %).

In the study group, 18 cases are male (72 %), 6 cases are female (24 %) and 1 case belonging to transgender (4 %). In study group, 2 cases are in 0 -20 age category(8%), 18 cases are of 20 - 40 age category(72 %), 4

cases are in 40 -60 age category(16 %), 0 cases are in 60 -80 age category(0 %), 1 case belongs to 80 -100 age category (4 %).

The mean values calculated for the serum thyroglobulin levels of all cases of neck compression is 1101.6 ng/ml with standard error of 367.4 ng/ml and The mean values calculated for the serum thyroglobulin levels for Hanging is 381.6 ng/ml with standard error of 90.1 ng/ml.

The Histopathological findings of the thyroid gland showed that one case of hanging showed Papillary carcinoma of thyroid and one case showed Hashimoto's thyroiditis causing false positive results of the serum thyroglobulin levels. So for calculating the true mean values of serum thyroglobulin these 2 cases are excluded.

The **true mean value** for serum thyroglobulin levels of **all cases of neck compression** are **1061.6 ng/ml** with standard error of 398.7 ng /ml

The true mean value for serum thyroglobulin levels for **Hanging** is **257.4 ng/ml** with standard error of 28.03 ng/ml with the highest being 536.8 ng/ml.

The mean values for serum thyroglobulin levels of for **ligature strangulation** is **4659.9 ng/ml** with standard error of 2094.2 ng/ml

The mean values for serum thyroglobulin levels of for **manual strangulation** is **5103.2 ng/ml** 539.6 ng/ml

The control group consists of 25 cases of death due to Natural causes, Poisoning, Road Traffic Accidents, Train traffic accidents and fall from height of 5 each. In the control group 13 cases were male and 12 cases were female. The mean values for serum thyroglobulin levels of the control group was 21.8 ng/ml.

In the study group ligature mark is marked in 61 % of the cases and ligature mark is faint in 39cases % of the cases in study group.

As in the ligature material used in hanging and strangulation, Nylon saree was used in 44 % cases , Nylon rope was used in 28 % cases, Thupattas was used in 12 % cases, cotton saree was used in 8 % cases , hands were used in 8 % cases.

Regarding cyanosis, it was present in 76 % cases and absent in 24 % cases. Petechial haemorrhages were seen in 88 % cases and were absent in 12 % cases of neck compression. Congestion was present in 80 % cases and absent in 20 % cases. Fluidity of blood was present only in 28 % cases and was absent in 72 % cases.

Regarding post-mortem interval, blood was collected in the first 0 – 36 hours in 64 % cases, 36 – 72 hours in 16 % cases and >72 hours in 20 % cases.

# **DISCUSSION**

## DISCUSSION

The very first goal of this study is to establish the correlation between the serum thyroglobulin level and the neck compression. As stated earlier, Thyroglobulin is a glycosylated protein produced only in the thyroid gland which can be released as a result of injury to the thyroid in deaths due to neck compression like hanging, manual strangulation and ligature strangulation.<sup>78</sup> As only a few studies have been conducted regarding this topic, it is very essential also to rule out the other possible causes of raised serum thyroglobulin levels in post-mortem.

In this study, The True mean value of the serum thyroglobulin level in neck compression is 1061.6 ng /ml with the standard error of mean as 398.7 ng /ml which is above the mean values of the serum thyroglobulin levels seen in other studies.<sup>75</sup>

The thyroglobulin is estimated by a highly sensitive Chemiluminescent immunoassay using Immulite analyser. It has an Analytical sensitivity of 0.01 ng /ml & Functional sensitivity 0.1 ng /ml.<sup>72</sup> The earlier studies were conducted by Precipitation electrophoresis, Radio Immunoassay (RIA), Enzyme linked Immunosorbent assay (ELISA).<sup>7, 9, 11</sup>

The Histopathological examination of the thyroid showed papillary carcinoma of thyroid in one case and Hashimoto's Thyroiditis so that they

are excluded while calculating the true mean value of serum thyroglobulin levels. These were recommended by the earlier studies which will strengthen the study.

The study involved two groups, one the study group involving the cases of death due to neck compression like hanging, manual strangulation, ligature strangulation and the control group with 25 cases totally with 5 cases each of death due to Natural cause, Poisoning, Road traffic accident, Train traffic accident and fall from height.

The mean value in control group is 21.8 ng /ml. The true mean value for serum thyroglobulin levels for Hanging is 257.4 ng/ml with standard error of 28.03 ng/ml with the highest being 536.8 ng/ml. The mean values for serum thyroglobulin levels of for ligature strangulation is 4659.9 ng/ml with standard error of 2094.2 ng /ml. The mean values for serum thyroglobulin levels of for manual strangulation is 5103.2 ng/ml with standard error 539.6 ng /ml.

There is marked variation between the serum thyroglobulin level of the control group and all the subgroups in the study group. Neck compression by any mode involves the rise of thyroglobulin. In cases of hanging there is a mild increase in thyroglobulin while there is a marked increase in thyroglobulin.

The mild increase in the thyroglobulin in hanging may be because of the level of the ligature mark above the level of thyroid cartilage. But in any case there will be a increase in thyroglobulin level. The level of the thyroglobulin may decrease as the half life of the thyroglobulin passes off. The normal half life of thyroglobulin is 65 hours.<sup>59</sup> This is also evident in the study with two of the cases of having 66.2 ng /ml and 53.9 ng/ ml when the post-mortem interval is 117 hours 30 minutes and 138 hours 10 minutes respectively.

The asphyxial findings like cyanosis (76 %), petechial haemorrhages (88 %), congestion (80 %) and fluidity of the blood (28 %) were not seen in all the cases of neck compression. So they are not specific and sensitive also. The ligature mark is seen well marked in 61 % cases and faint ligature mark is seen in 39 % cases. In cases of faint ligature mark the serum thyroglobulin level may be very helpful in arriving at the cause of death if the asphyxia findings are also not present in the cases of neck compression.



From this study, the mean values of the serum thyroglobulin levels in cases of death due to

- Neck compression is  $1061.6 \pm 398.7$  ng / ml
- Hanging is  $257.4 \pm 28.03$  ng/ml
- Ligature strangulation is  $4659.9 \pm 2094.2$  ng/ml
- Manual strangulation is  $5103.2 \pm 539.6$  ng/ml

The mean value of the serum thyroglobulin levels in the control group is  $21.8 \pm 2.71$  ng/ml.

These mean values shows there is an increase in the levels of serum thyroglobulin in cases of death due to neck compression against the levels of serum thyroglobulin in cases of death due to other causes in the control group.

It is also evident that the increase in the serum thyroglobulin level in manual strangulation is much higher than the levels in ligature strangulation. it may be due to the extent and duration of the direct pressure over the thyroid gland by the hands in cases of manual strangulation and by the ligature material in cases of ligature strangulation.

# CONCLUSION

## CONCLUSION

The aim of the study is to establish correlation between the Serum Thyroglobulin level and neck compression to help the forensic pathologist in precarious situation when none of the so called asphyxial findings can be seen in the postmortem. This is evident on analysing the results of the study when the mean values of the serum thyroglobulin levels are way higher in cases of neck compression when compared with the mean values of the control group.

The results of the study also shows that there is only a mild increase in the thyroglobulin levels in cases of death due to hanging compared to the marked increase as in cases of strangulation. This may be due to the position and duration of pressure of thyroid gland by the ligature material. In strangulation , manual strangulation accounts for much rise in the levels of serum thyroglobulin when compared to ligature strangulation. This may be due to the amount and location of pressure over the thyroid gland

This study also signifies the usage of histopathology of the thyroid gland to rule out the false positive rise of thyroglobulin levels by Carcinoma thyroid and Hashimoto's thyroiditis. The study can be extended with the estimation of the levels of Thyroid stimulating hormone, Free Thyroxine and

Free Tri Iodo Thyronine levels to evaluate the effects of hormones in the rise in thyroglobulin levels.<sup>70</sup>

As science and technology improves, the usage of scientific methods and markers to diagnose has to be there not only on the treatment aspect of the patient but also on the medicolegal aspect. The serum thyroglobulin can be used a marker in postmortem to diagnose neck compression. As such there are many biochemical markers that can be used in postmortem to diagnose the cause of death. But these markers has also to be cost effective to be used in developing countries like India.

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# **ANNEXURES**

# **COLOUR PLATES**

**Fig.8 Showing ligature abrasion in a deceased died due to ligature strangulation**



**Fig.9 showing ligature abrasion in left lateral view**



**Fig.10 Showing ligature abrasion at the back of the neck**



**Fig. 11 Showing contusion in the muscles of the neck**





**Fig .12 showing anteroposterior compression fracture of the superior horn of the hyoid bone in case of ligature strangulation**



**Fig.13 showing anteroposterior compression fracture with outward movement**



**Fig.14 showing hanging of the deceased with heavy nylon rope in scene of crime**





**Fig.15 showing ligature material – Nylon rope**



**Fig.16 showing patterned ligature abrasion with the nylon rope**



**Fig.17 showing ligature material – Nylon rope**



**Fig.18 showing ligature abrasion with the nylon rope**





**Fig.19 showing ligature material – Nylon saree**



**Fig.20 showing faint ligature abrasion with the nylon saree**



**Fig.21 showing ligature material - Thupatta**



**Fig.22 showing faint ligature abrasion using Thupatta**





**Fig.23 showing dissection of neck in a case of death due to hanging**



**Fig.24 showing dissected out thyroid gland in autopsy**



**Fig.25 showing cyanosis in a case of death due to neck compression**

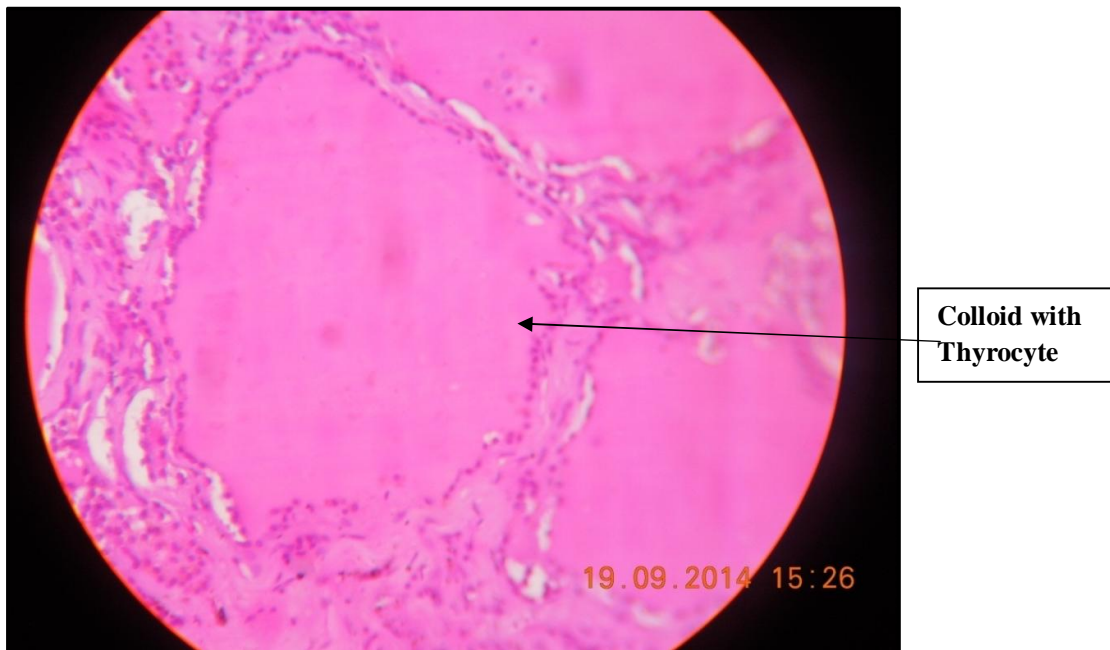


**Fig.26 showing Petechial haemorrhages on the anterior surface of lungs in case of death due to neck compression**

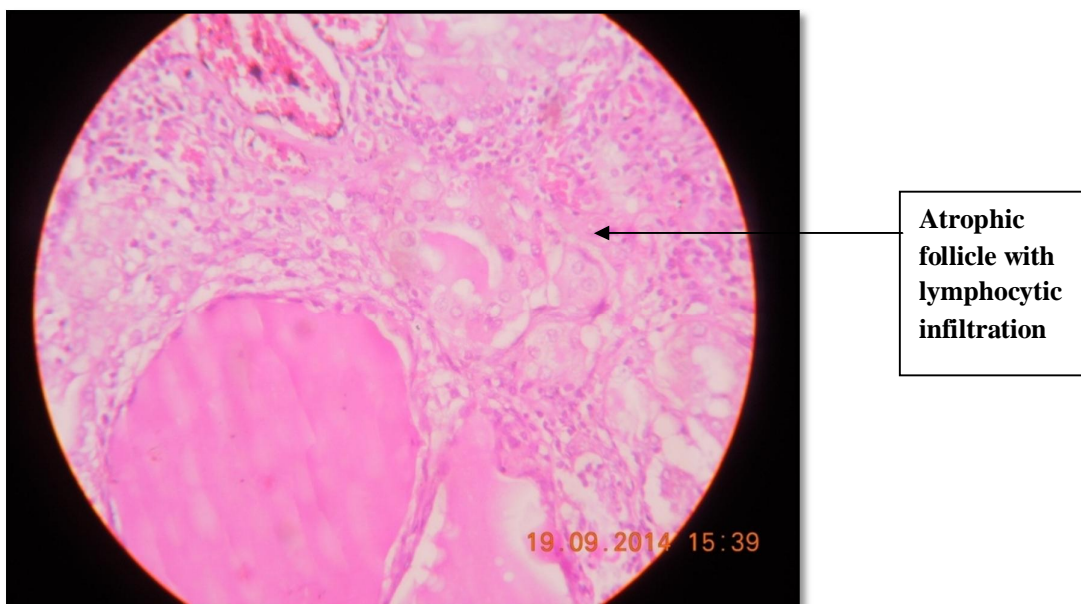




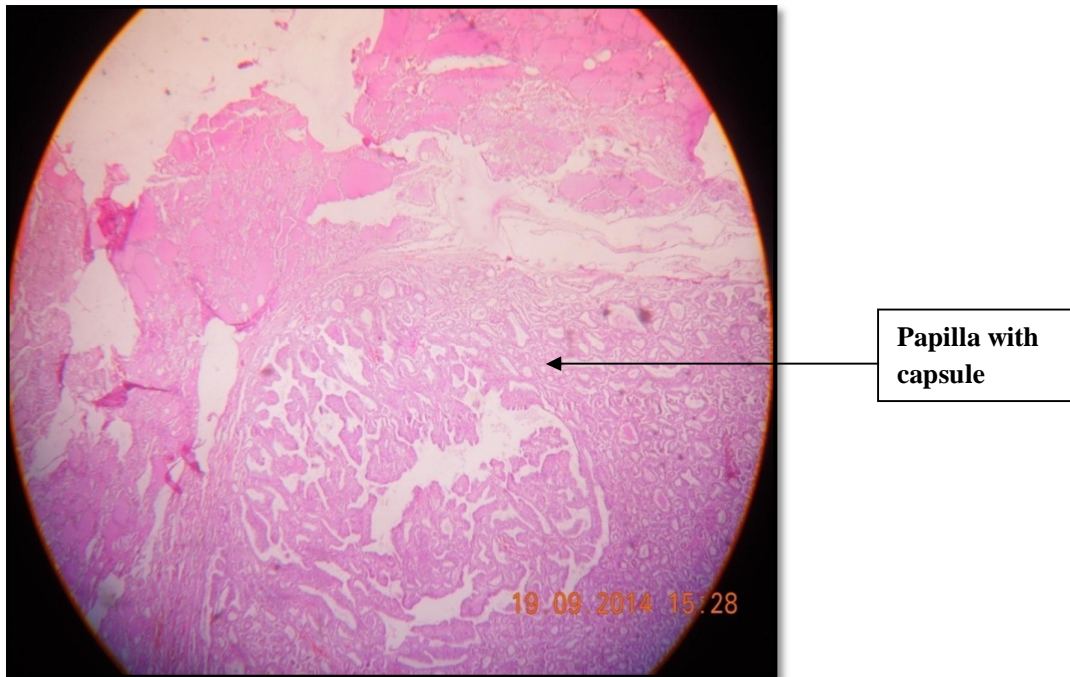
**Fig.27 showing Normal Histopathology of the thyroid gland**



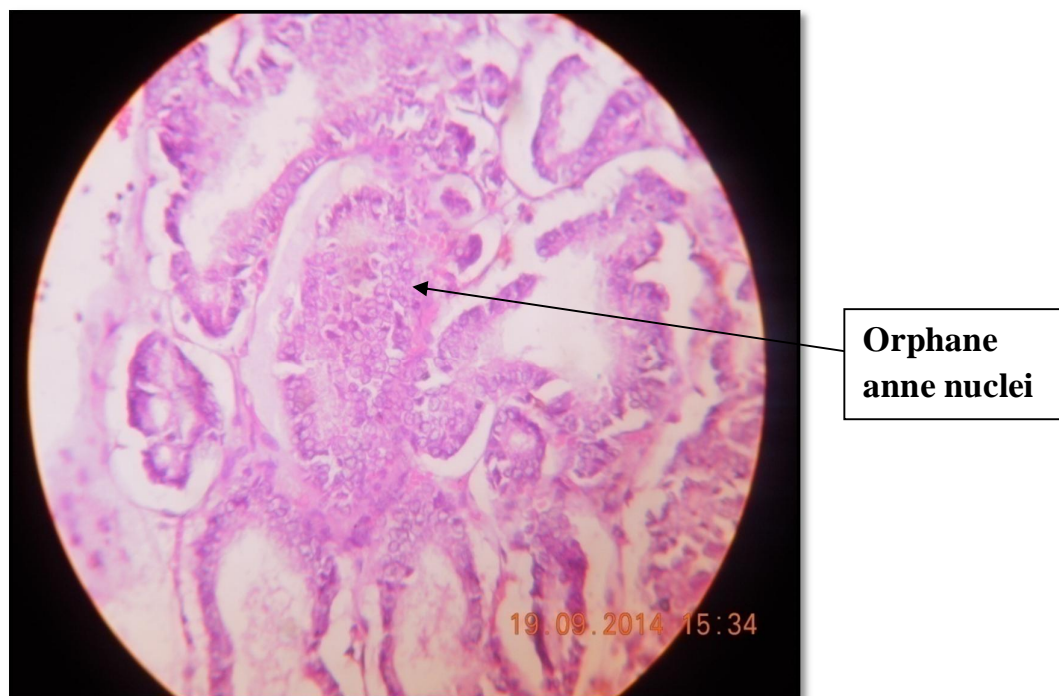
**Fig.28 showing Hashimoto's thyroiditis with lymphocytic infiltration**



**Fig.29 showing Encapsulated Papillary carcinoma of thyroid**



**Fig.30 showing Orphan anne nuclei –  
Characteristic of Papillary carcinoma of thyroid**



# **MASTER CHART**

## Study Group

S.No	P.M. No.	Age	Sex	Hanging/Strangulation	Serum Thyroglobulin level( ng / ml)	HPE Result	PM interval	Ligature material	Ligature mark	Cyanosis	Petechial hemorrhages	congestion	Fluidity of blood
1.	805 /14	36	M	Hanging	245.4	Normal	12 h 45 m	Nylon Rope	Yes Marked	Yes	Yes	Yes	No
2.	867 /14	60	M	Hanging	198.2	Normal	5 h 30 m	Nylon Saree	Yes Marked	Yes	Yes	Yes	No
3.	888 /14	90	M	Hanging	367.2	Normal	16 h 20 m	Nylon Saree	Yes Marked	Yes	Yes	Yes	No
4.	920 /14	40	M	Hanging	193.2	Normal	16 h 35 m	Nylon Saree	Yes Faint	No	Yes	Yes	No
5.	1053 /14	32	M	Manual Strangulation	4563.6	Normal	24 h 10 m	Hands	No	Yes	Yes	Yes	No
6.	1066 /14	36	M	Hanging	467.2	Normal	33 h 10 m	Nylon Saree	Yes Marked	Yes	Yes	Yes	Yes
7.	1106 /14	27	TG	Hanging	241.7	Normal	19 h 25 m	Nylon Saree	Yes Faint	No	Yes	No	No
8.	1112 /14	32	M	Hanging	1780.1	Papillary Ca.	81 h 10 m	Thupatta	Yes Marked	Yes	Yes	Yes	Yes
9.	1122 /14	32	F	Hanging	289.3	Normal	6 h 10 m	Nylon Saree	Yes Faint	No	Yes	Yes	No
10.	1173 /14	34	M	Manual Strangulation	5642.9	Normal	15 h 30 m	Hands	No	No	Yes	Yes	Yes
11.	1178 /14	21	M	Ligature Strangulation	2565.7	Normal	36 h 20 m	Nylon Rope	Yes Marked	Yes	Yes	Yes	No
12.	1181 /14	54	M	Hanging	536.8	Normal	15 h	Nylon Rope	Yes Marked	Yes	Yes	Yes	Yes
13.	1213 /14	29	F	Hanging	1342.3	Hashimoto's	20 h 45 m	Cotton Saree	Yes Marked	Yes	Yes	Yes	No
14.	1221 /14	36	M	Hanging	187.3	Normal	72 h 40 m	Nylon Saree	Yes Faint	Yes	Yes	Yes	No
15.	1234 /14	42	M	Hanging	126.3	Normal	6 h 10 m	Thupatta	Yes Faint	No	No	No	No
16.	1244 /14	26	F	Ligature Strangulation	6754.1	Normal	54 h 35 m	Nylon Rope	Yes	Yes	Yes	Yes	Yes
17.	1248 /14	34	F	Hanging	66.2	Normal	117 h 30 m	Nylon Rope	Yes Marked	Yes	Yes	Yes	No
18.	1292 /14	28	F	Hanging	347.3	Normal	17 h 30 m	Nylon Saree	Yes Faint	Yes	Yes	Yes	No
19.	1294 /14	18	F	Hanging	298.5	Normal	17 h 55 m	Thupatta	Yes Marked	Yes	No	Yes	No
20.	1341 /14	32	M	Hanging	201.3	Normal	72 h 40 m	Cotton Saree	Yes Marked	No	No	No	No
21.	1383 /14	40	M	Hanging	53.9	Normal	138 h 10 m	Nylon Rope	Yes Faint	Yes	Yes	Yes	Yes
22.	1390 /14	17	M	Hanging	267.8	Normal	16 h 25 m	Nylon Saree	Yes Marked	Yes	Yes	Yes	Yes
23.	1415 /14	24	M	Hanging	341.7	Normal	28 h 10 m	Nylon Rope	Yes Marked	Yes	Yes	Yes	No
24.	1451 /14	45	M	Hanging	276.5	Normal	36 h 10 min	Nylon Saree	Yes Faint	Yes	Yes	No	No
25.	1469 /14	27	M	Hanging	186.2	Normal	64 h 10 m	Nylon Saree	Yes Faint	Yes	Yes	No	No



## Control Group

S.No.	PM.No.	Age	Sex	Manner of death	Cause of death	Serum thyroglobulin level(ng /	HPE Result	PM interval	Cyanosis	Petechial hemorrhages	congestion	Fluidity of blood
1.	901/14	43	M	Natural Cause	MI	23.3	Normal	47 h 10 m	Yes	Yes	Yes	No
2.	904/14	19	F	Natural Cause	TB	11.2	Normal	10 h 30 m	Yes	Yes	Yes	No
3.	912/14	34	F	Natural Cause	TB	14.4	Normal	72 h 2 m	No	Yes	Yes	No
4.	913/14	45	M	Natural Cause	MI	9.2	Normal	56 h 45 m	No	Yes	Yes	No
5.	914/14	60	F	Natural Cause	MI	35.8	Normal	36 h 10 m	Yes	Yes	Yes	No
6.	916/14	57	F	Poisoning	Poisoning	14.2	Normal	15 h 30 m	Yes	Yes	Yes	Yes
7.	931/14	27	M	Poisoning	Poisoning	34.4	Normal	36 h 20 m	No	Yes	No	No
8.	967/14	22	F	Poisoning	Poisoning	33.2	Normal	15 h	Yes	Yes	Yes	Yes
9.	970/14	57	F	Poisoning	Poisoning	4.5	Normal	20 h 45 m	No	Yes	Yes	No
10.	980/14	27	F	Poisoning	Poisoning	15.6	Normal	72 h 40 m	No	Yes	Yes	Yes
11.	941/14	58	F	RTA	Multiple Injuries	2.3	Normal	6 h 10 m	Yes	Yes	Yes	No
12.	977/14	45	M	RTA	Multiple Injuries	33.2	Normal	16 h 25 m	Yes	Yes	Yes	Yes
13.	978/14	24	F	RTA	Bhnt Injury Abdomen	44.1	Normal	28 h 10 m	Yes	Yes	Yes	No
14.	990/14	45	F	RTA	Head Injuries	14.6	Normal	36 h 10 m	No	Yes	Yes	No
15.	900/14	26	M	RTA	Head Injuries	3.1	Normal	64 h 10 m	No	No	No	No
16.	905/14	28	M	TTA	Multiple Injuries	34.6	Normal	16 h 35 m	Yes	Yes	Yes	Yes
17.	910/14	44	M	TTA	Multiple Injuries	22.1	Normal	24 h 10 m	Yes	Yes	Yes	No
18.	933/14	45	M	TTA	Multiple Injuries	34.4	Normal	33 h 10 m	Yes	Yes	Yes	No
19.	896/14	27	F	TTA	Multiple Injuries	1.5	Normal	19 h 25 m	Yes	No	Yes	No
20.	873/14	25	M	TTA	Multiple Injuries	26.6	Normal	81 h 10 m	No	No	No	No
21.	926/14	20	M	Fall From Height	Head Injuries	34.3	Normal	36 h 20 m	No	Yes	Yes	Yes
22.	927/14	53	F	Fall From Height	Multiple Injuries	12.3	Normal	15 h	Yes	Yes	Yes	Yes
23.	932/14	65	M	Fall From Height	Head Injuries	14.2	Normal	20 h 45 m	Yes	Yes	Yes	No
24.	962/14	65	M	Fall From Height	Head Injuries	49.1	Normal	72 h 40 m	Yes	Yes	No	No
25.	903/14	45	M	Fall From Height	Multiple Injuries	23.1	Normal	6h 10 m	Yes	Yes	No	No